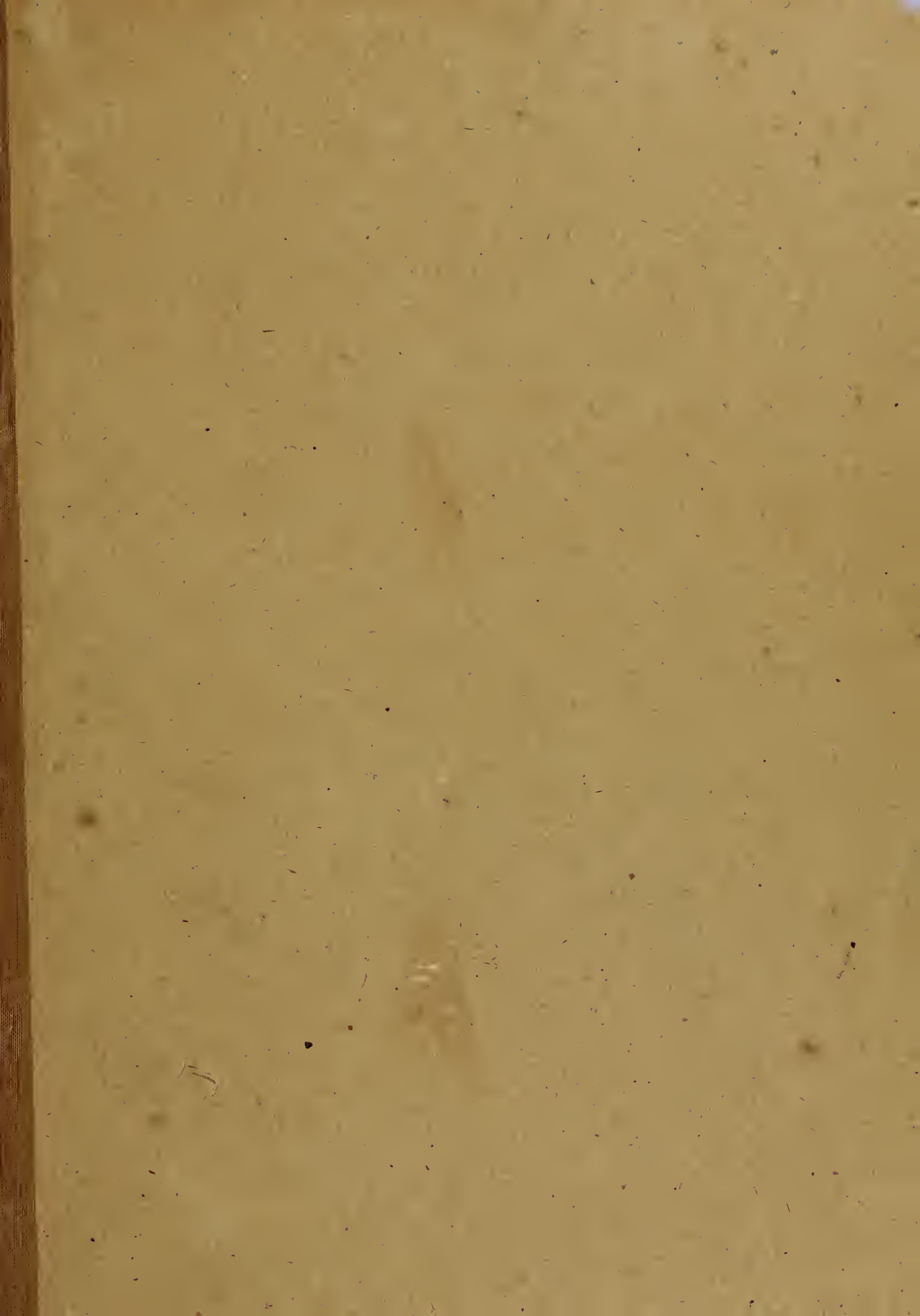
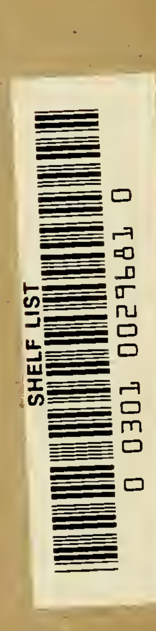



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Unter Mitwirkung zahlreicher Fachgenossen

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Preface.

The preparation of the normal tables and plates on *Necturus* was begun several years ago by Professor C. O. WHITMAN but on account of unavoidable circumstances the work was delayed. It was later taken up by Professor EYCLESHYMER upon the suggestion of both Professor WHITMAN and Professor KEIBEL. While Professor WHITMAN has not directly participated in the later work, he has furnished the senior author with material and information without which it would have been impossible to complete the work. In the completion of the work the senior author has been fortunate in having the able coöperation of Professor JAMES M. WILSON.



Table of Contents.

Description of Illustrations.

The series of eggs, embryos and larvae of *Necturus*, from which the following descriptions and the appended illustrations were made, were collected May 15th, 1903 and kept at a water temperature of 17°—18° C. The illustrations are copied from the original water colored pictures which were made by Mr. LEONARD H. WILDER, under the direction of the senior author. It should be emphasized that the ages, measurements and illustrations are all made from the living objects.

Fig. 1. (× 10.)

Side view of egg 1 day 4 hrs. after deposition. The first cleavage groove has reached the lower pole of the egg. Second grooves extend to level of the equator of the egg.

Fig. 2. (× 10.)

Side view of egg 1 day 8 hrs. after deposition. The second cleavage grooves have reached the equator. The grooves of the third cleavage pass in meridional planes, but have not yet reached the equator.

Fig. 3. (× 10.)

Side view of egg 1 day 12 hrs. old. Five cleavage grooves have reached lower pole, dividing lower hemisphere into six segments.

Fig. 4. (× 10.)

Side view of egg 1 day 16 hrs. old. The greater number of cleavage grooves pass in meridional planes, many are latitudinal and some nearly radial. The upper surface of the egg shows sixteen segments, the lower nine.

Fig. 5. (× 10.)

Side view of egg 1 day 20 hrs. old. The upper surface of the egg shows some fifty segments, the lower nine.

Fig. 6. (× 10.)

Side view of egg 2 days 2 hrs. old. The upper surface of the egg shows more than one hundred segments, the lower twelve.

Fig. 7. (× 10.)

Side view of egg 2 days 7 hrs. old. The upper surface of egg shows about two hundred cells. The lower portion is in about same stage as described in Fig. 6.



Fig. 8. (× 10.)

Side view of egg 2 days 12 hrs. old. The upper surface of egg shows some five hundred cells, the lower about forty.

Fig. 9. (× 10.)

Top view of egg 4 days 4 hrs. old. Segmentation cavity shows through thin translucent roof. Blastopore not present.

Fig. 10. (× 10.)

Bottom view of egg 6 days 16 hrs. old. Crescentic blastopore. Line of invagination sharply separates large yolk cells from small cells of blastodisc.

Fig. 11. (× 10.)

Dorso-lateral view of egg 10 days 10 hrs. old. Large circular blastopore; faint indication of embryonic anlage.

Fig. 12. (× 10.)

Side view of egg 10 days 16 hrs. old. Large circular blastopore. Anlage of mesial portion of embryo above dorsal lip of blastopore. Segmentation cavity faintly outlined.

Fig. 13. (× 10.)

Top view of egg 13 days 3 hrs. old. Small circular blastopore. Embryonic anlage triangular in outline; lateral boundaries indistinct. First appearance of neural groove. Roof of segmentation cavity thinner, making its boundaries distinct.

Fig. 14. (× 10.)

Top view of egg 14 days 4 hrs. old. Blastopore smaller, lateral margins of anterior portion of embryo bounded by short broad ridges which are the beginnings of the lateral portions of the neural fold. At anterior margin of embryo there is a transverse crescentic ridge which is beginning of transverse portion of neural fold. Neural groove deep but does not extend either to transverse portion of neural fold or to blastopore. Segmentation cavity crescentic.

Fig. 15. (× 10.)

Top view of egg 14 days 19 hrs. old. Blastopore much reduced, circular. The yolk plug is not visible in this egg. Lateral and transverse portions of neural fold united to form continuous fold around anterior portion of embryo. Lateral boundaries of posterior portion of embryo not defined. Neural groove not as long, nor as distinct as in preceding stage. Dark crescentic area in front of embryo is segmentation cavity.

Fig. 16. (× 10.)

Top view of egg 15 days 15 hrs. old. Blastopore small, circular; yolk plug visible. Neural fold prominent, its free ends extend nearly to blastopore. Neural groove deep and narrow at anterior end, broad and shallow at posterior end, fades out just in front of blastopore. A part of the segmentation cavity is still apparent in front of the embryo.

Fig. 17. (× 10.)

Top view of egg 16 days 6 hrs. old. Blastopore reduced to a very minute circular aperture. Neural plate narrower than in preceding stage. Neural fold prominent, its free ends coalescing at blastopore.

Neural groove extends to transverse portion of fold but does not reach blastopore. Segmentation cavity no longer visible in surface views.

Fig. 18. (× 10.)

Top view of embryo 17 days 2 hrs. old. Blastopore an elongated narrow aperture between ends of neural fold. Neural plate narrower than in preceding stage. The constricted portion represents in a general way the division between head and trunk. Neural fold most prominent in head region.

Fig. 19. (× 10.)

Top view of egg 17 days 17 hrs. old. Blastopore no longer visible. Neural plate narrowest posteriorly; broad in head region, showing boundary zone between head and trunk. Lateral portions of fold coalesced at posterior end of embryo. At anterior end of embryo a deep groove partially separates the two halves of the neural fold.

Fig. 20. (× 10.)

Top view of egg 18 days 13 hrs. old. Lateral portions of neural fold almost united except in head region where they are still widely separated. In the antero-lateral portions of the fold are slight evaginations which are the beginnings of the optic vesicles.

Fig. 21. (× 10.)

Top view of egg 18 days 15 hrs. old, 3 or 4 pairs of myotomes. Lateral portions of neural fold widely separated in head region, more closely approximated in anterior trunk region, coalesced in tail.

Fig. 22. (× 10.)

Dorso-lateral view of embryo 20 days 10 hrs. old, length 6 mm, 6 pairs of myotomes. Outline of body conforms to curvature of egg. Head end of embryo shows three longitudinal ridges; middle ridge lies slightly above level of lateral ridges. The middle one is common anlage of fore, mid and hind brain. The lateral ones are the common anlage of the optic vesicles and branchial arches. Anus formed.

Fig. 23. (× 10.)

Side view of embryo 21 days 2 hrs. old, length 7 mm, 10—12 pairs of myotomes. General outline of body conforms to curvature of egg. Head slightly raised above surface of yolk. Slight enlargement at end of tail. A distinct enlargement of anterior end of head shows optic vesicles; just posterior to this enlargement is the anlage of the branchial arches. Anus shows just below tip of tail.

Fig. 24. (× 10.)

Dorso-lateral view of embryo 22 days 17 hrs. old, length 8 mm, 16—18 pairs of myotomes. Embryo much curved laterally. Anterior half of head free from yolk. Caudal enlargement more prominent. Optic vesicles and mandibular arch well defined. The hyoid and first branchial arches are discernible; also the common anlage of the second and third branchial arches.

Fig. 25. (× 5.)

Side view of embryo 23 days 10 hrs. old, length 9 mm, 20—22 pairs of myotomes. General outline of the body straighter. Head free from yolk. Caudal enlargement becoming free. Optic vesicles and forebrain much larger. Mandibular, hyoid, first branchial, and common anlage of second and third branchial arches well defined. Otic vesicle visible above hyoid arch.

Fig. 26. (× 5.)

Side view of embryo 24 days 22 hrs. old, length 10 mm, 23—24 pairs of myotomes. General outline of body of embryo straighter, less curved laterally. Head and caudal extremities free from yolk. Yolk becoming oval. Optic vesicles prominent. Ear better defined. Olfactory pits present. The mandibular, hyoid and first branchial arches are distinct. The second and third branchial arches are not yet differentiated, a slight process on the first branchial indicates the beginning of the gill bar. The anlage of the heart is visible just beneath the arches.

Fig. 27. (× 5.)

Side view of embryo 26 days old, length 11 mm, 26—27 myotomes. General outline of body straighter than in preceding stage. Head projects some 3 mm beyond margin of yolk; tail projects 1.2 mm, is thinner laterally but broader dorso-ventrally. Eye, ear, nasal pits and mouth well defined. Maxillary process discernible. Mandibular arches longer, but ventral ends widely separated. Second and third branchial arches formed. Gill bars present on three branchial arches. Anterior limb buds indicated; faint anlage of posterior limb buds. Yolk pear-shaped. Heart prominent. First surface capillaries present although not indicated in figure.

Fig. 28. (× 5.)

Side view of embryo 30 days 8 hrs. old, length 13 mm, 30—31 myotomes. The trunk of the embryo is nearly straight. At level of the posterior gill there is a pronounced neck bend and at the level of the posterior limbs a striking downward bend of the tail. The epiphysis shows in surface views. The lens is discernible. The ear is still visible. The external nasal openings are sharply defined. The boundaries of the mouth are better outlined owing to the approximation of the ventral ends of the mandibular arches. The hyoid arch is becoming obscured. The gill bars are prominent on the three branchial arches. The anterior limb buds project dorsally about .5 mm above the surface of the body. The posterior limb buds are but slight elevations. The yolk is pear-shaped with its dorsal surface much flattened. The auricular and ventricular portions of the heart are apparent. The surface of the yolk is covered by a dense network of capillaries which for the most part convey blood antero-ventrally to the abdominal vein. Considerable pigment is present in the trunk region although but little has reached the outer portion of the dermis.

Fig. 29. (× 5.)

Side view of embryo 36 days 16 hrs. old, length 16 mm, 36—38 myotomes. In general outline the embryo shows a number of striking changes. The neck bend is not so pronounced. The tail bend is scarcely noticeable. There is a striking increase in dorso-ventral width of tail. The cerebral hemispheres are well defined. The eye is now prominent and the lens better defined. The ear is no longer visible in surface views. The mouth is well defined. The ends of the mandibular arches are closely approximated but not united. The hyoid and branchial arches are more obscure. Anlagen of gill filaments present on gill bars. Anterior limbs project dorsally. Posterior limbs are short ridges extending in horizontal plane. The yolk is elongated and reduced in diameter both dorso-ventrally and laterally. Surface blood vessels as in preceding stage, excepting that they are now apparent in the gill bars. The chromatophores are most numerous in the anterior and dorsal portions of the head.

Fig. 30. (X 5.)

Side view of embryo 40 days 20 hrs. old, length 18 mm, 44—46 myotomes. The outline of the body shows a marked ventral curvature of the trunk, less pronounced neck bend, and further increase in the dorso-ventral width of the tail. The eye is very prominent owing to the pigment in the retina. Ear not visible externally. Nasal openings very small. The mandibular arches have coalesced. The boundaries of the other arches are no longer discernible. Gill filaments well developed. Anterior limbs about 1 mm long project dorso-posteriorly. The yolk is elongated oval. Abdominal vein and branchial blood vessels prominent. Pigment present in dorsal portion of head, also along dorsal and lateral portions of trunk and tail. The yolk is unpigmented excepting along dorsal margin.

Fig. 31. (X 5.)

Side view of larva 49 days old, length 21 mm. General outline of body decidedly different. Head bend obliterated, slight upward curve in trunk. Tail broader. Eye more deeply pigmented. Gill bars very long, extending to level of end of anterior limb. From three to five lateral filaments on each gill bar. Anterior limbs project postero-ventrally; three digits formed. Posterior limbs directed caudad; no trace of digits. Yolk much elongated. Network of capillaries denser. Large lateral arteries, at level of upper margin of yolk, very prominent. Well defined longitudinal bands of pigment.

Fig. 32. (X 5.)

Side view of larva 61 days old, length 25 mm. General outline of body shows less dorsal curvature of trunk. Tail much longer in proportion to length of trunk and much broader dorso-ventrally. Gill bars longer, each posessing six to eight lateral filaments. Anterior and posterior limbs directed postero-ventrally. Anterior 3 mm long, posterior 2 mm long. Each limb shows four digits. The distribution of pigment is essentially similar to that observed in the 21 mm larva, the bands however are more sharply defined. Chromatophores in the gill bars and limbs and beginning to extend over the dorsal surface of the yolk.

Fig. 33. (X 5.)

Side view of larva 70 days 4 hrs. old, length 28 mm. The general outline of the body is slenderer than at any time preceding. The rapid absorption of the yolk has brought its ventral surface nearly to the level of the ventral surfaces of the head and tail. The gill bars curve dorsally and possess from ten to twelve pairs of lateral filaments. The tail is somewhat constricted at the level of the posterior limbs. The limbs and digits are better developed and are now used in locomotion. Pigmentation is denser than in 25 mm larva, but same general arrangement of bands prevails.

Fig. 34. (X 5.)

Side view of larva 97 days old, length 34 mm. In general outline the larva begins to resemble the adult. The yolk is well absorbed. The tail is very broad and now used as a powerful caudal fin in swimming. The gill bars project dorsally and have a large number of filaments. The legs project far below the ventral surface of the body. In color the same general pattern prevails as in the 28 mm larva.

There are some minor changes, the light band is broader and better defined, and extensions of pigment over the yolk have been so uneven that a number of irregular oval areas are left unpigmented, causing a mottled appearance in this region.

Fig. 35. (× 5.)

Side view of larva 126 days old, length 39 mm. The young *Necturus* now conforms in outline to the adult. In color however it is decidedly different.

Introduction to Tables.

The material upon which the normal tables are based was collected in 1903. At the time the illustrations were made from the living material, several specimens of the same stages were fixed in various solutions. Among these 10 % formalin caused the least distortion. This formalin-fixed material proved most satisfactory for work not involving cytological study. The material was stained *in toto* with haematoxylin, imbedded in paraffin and counterstained on the slide with weak picric acid, orange G or eosin. Unless otherwise stated the above fixation and staining have been used. Each of the stages designated in the following tables was sectioned in transverse, horizontal and sagittal planes. Besides these series many others have been consulted in which the material was fixed and stained by other methods. The total number of series at our disposal was upwards of 250.

Tables.

Stage	Series	Length	Age	Blastomeres	Yolk
1	1		1 day 4 hrs.	2	
2	4		1 day 8 hrs.	6	
3	6		1 day 12 hrs.	12	Lower portion six surface grooves.
4	10		1 day 16 hrs.	20—24	Lower portion nine surface grooves; none reach center of egg.
5	12		2 days 2 hrs.	80—100	Lower portion twelve surface grooves; few reach center of egg.
6	18		2 days 7 hrs.	200—250	Lower surface as above excepting several grooves reach center of egg.
7	20		2 days 12 hrs.	500—600	Lower portion forty surface grooves; yolk much segmented.
8	25		6 days 16 hrs.		
9	28		10 days 16 hrs.		
10	35		13 days 3 hrs.		
11	38		14 days 4 hrs.		
12	40		14 days 19 hrs.		
13	48		15 days 10 hrs.		
14	55		16 days		
15	65		16 days 10 hrs.		
16	69		17 days		
17	73		17 days 17 hrs.		
18	85		18 days 15 hrs.		

Segmentation cavity	Blastopore. Anus	Archenteron. Enteron. Mesoderm. Chorda	Neurenteric canal	Nervous system. Optic vesicles. Somites	Stage
					1
					2
Present, large; roof single layer thick.					3
Large, roof in part two layers thick.					4
Segmentation cavity larger, roof in part two layers thick.					5
Segmentation cavity large, roof in part three layers thick.					6
Roof thinner, four layers around periphery, single layer in center.					7
Well formed.	Crescentic fissure on ventro-lateral portion of egg.	Archenteron just beginning.			8
Smaller.	Horse-shoe-shaped.	Archenteron extends over about 20°. Peristomal mesoblast present at dorsal lip of blastopore.			9
Smaller.	Circular.	Archenteron extends over about 45°. Dorsal wall posteriorly two layers. Peristomal mesoblast well defined in ventral lip of blastopore.			10
Quite small.	Small, circular, yolk plug externally visible.	Archenteron nearly complete; dorsal wall two layers anteriorly. Mesoblast around entire blastopore. Anlage of chorda.	Present.	Broad neural plate of thickened ectoblast; shallow neural groove.	11
Very small.	Very small, circular, yolk plug externally visible.	Archenteron very nearly complete; single layer in mid-longitudinal axis; this layer is beginning of chorda. Paraxial mesoblast co-extensive with chorda.	Present.	Low neural ridges present, deep neural groove.	12
Very small.	Elongated dorso-ventrally; yolk plug not externally visible.	Lateral walls of enteron three layers. Somatic and splanchnic layers well defined. Chorda well defined in head region.	Present, small.	Higher neural ridges, deep neural groove.	13
Very small.	Yolk plug not present.	Enteron single-layered dorsal wall; mesoblast extends ventrally over one-half of egg. Chorda narrower, thicker.	Tubular.	Prominent neural folds approaching each other, deep neural groove.	14
Not present (?).		Walls of enteron as above. Mesoblast extends to ventral portion of egg; well defined coelom. Chorda anteriorly a rod of cells.	Small canal.	High neural ridges approximating, but nowhere in contact.	15
Small, well defined.		Chorda oval or round in cross section throughout head and trunk regions, undifferentiated in tail.	Widely open.	Neural ridges meet in anterior head region. Beginning of optic vesicles.	16
(?)	Anus perforate.	Enteron as above. Mesoblast over ventral surface of egg. Chorda well defined in head and trunk regions.	Closed (?).	Neural ridges not closed in head region but coalesced in posterior trunk region and in tail. Optic vesicles better defined.	17
Present as large spaces among yolk cells.				Neural folds closed throughout entire length of embryo. Optic vesicles prominent, outer wall single layer of cells. Three or four somites.	18

Stage	Series	Length	Age	Body Form	Somites	Notochord	Nervous System	Eye	Ear
19	100 Trans. 101 Trans.	6 mm	20 days 10 hrs.	Outline of body conforms to curvature of egg; extends over 160° of circumference of egg.	Externally 6 pairs of segments, those in anterior trunk region roughly triangular in cross sections. Myocoele present. Muscle plate and cutis plate well defined. Clear zone at ends of muscle plate.				
19a		6½ mm							
20	102 Trans. 103 Sag.	7 mm	21 days 2 hrs.	Body covers 180° of circumference of egg. Head end of embryo slightly elevated above surface of yolk. Distinct enlargement of anterior end shows optic vesicles. Tail end enlarged to form slight knob.	Externally 10 to 12 pairs of myotomes. In anterior trunk region muscle and cutis plate better defined, otherwise as in 6 mm stage.	Notochord anteriorly a solid rod of cells. Extends slightly in front of ear. Posteriorly not free from ectoderm or entoderm.	Neural tube closed throughout entire length; enlarged at anterior end. Fore brain, mid brain and hind brain indicated. Anlage of telencephalon. Fore brain nearly at right angles with mid brain; prominent, oval in transverse section; walls thin, cavity large. Mid brain long; oval in transverse section; canal narrow transversely. Optic stalk short, hollow. Chiasma well defined. Torus transversus small. Infundibulum moderate size. No plexus. No commissures. Anlage of trigeminal ganglion, also acusticus, facialis and vagus. Spinal cord long oval in section. Anlage of spinal ganglia. Caudally, notochord, dorsal wall of gut and neural tube fuse into common mass of cells.	Primary optic vesicles better defined; grown slightly backward; outer wall flattened and thickened forming anlage of retina; open widely into third ventricle. Anlage of lens as slight thickening of ectoderm. No mesoderm between lens and vesicle.	Otic vesicle just closed, spherical, lies between ectoderm and hind brain. Cells elongated in ventral part their inner ends free from yolk. Acustico-facialis ganglion lies ventro-cephalad of vesicle and is nearly as large as vesicle.
21	105 Trans.	8 mm	22 days 18 hrs.	Embryo curved laterally. Anterior half of head free from yolk. Optic vesicles well defined.	Externally 14 to 16 pairs myotomes.	Well defined throughout anterior and middle portion of body; extends slightly in front of level of ear. Anterior portion lies in contact with medullary tube. Long tract of mesenchyma between anterior end of chorda and hypophysis; fused with entoderm and ectoderm in posterior portion. Anlage of sheath. Indications of hypochorda.	Cranial flexure well marked. Divisions of brain better defined. Medulla longer than fore brain and mid brain together. In roof of fore brain, paraphysial arch, postvelar arch and epiphysial arch formed. Beginning of velum transversum. Trigeminal nerve forming branches. Roof of medulla a single layer of flattened cells; nerve fibers forming in Gasserian ganglion. Spinal cord oval in section. Canal wide, constricted at sides. Roof plate thinner than floor plate. Cells still contain large yolk granules. Spinal ganglia have grown down nearly to middle of side of cord.	Vesicle larger. Beginning of optic cup. Inner layer thinner; outer or retinal layer slightly concave. Optic stalk somewhat constricted.	Vesicle completely closed, slightly pear-shaped, smaller end dorsal. In contact with ectoderm.
22	106 Trans. 107 Sag. 110 Front	9 mm	23 days 10 hrs.	Head end elevated. Optic vesicles larger. Mandibular, hyoid, first branchial and common anlage of second and third branchial arches well defined. Caudal enlargement more pronounced. Embryo in contact with yolk over 140°. Curved laterally.	Externally 20 to 22 pairs of myotomes. In anterior trunk region, muscle plate nearer notochord. Clear zones at ends of plate wider, fibrillae present in myoblasts.	Extends from a point slightly in front of ear to tip of tail. Vacuolated anteriorly, not posteriorly. Separated from neural tube, fore gut and hypophysis by mesenchyma. Posteriorly notochord, neural tube and entoderm fused into common mass. Unsegmented. Hypochorda well defined.	Flexure showing in mid brain. Hemispheres well developed; walls thinner; ventricle very large. Beginning of epiphysis. Velum transversum deeper. Infundibulum forming. Optic chiasma well defined, also torus. Roof of mid brain thin, ventricle widest in dorsal portion. Auditory nerve well developed. Trigeminal ganglion has two branches, one running over eye, other anterior to first gill. Peripheral band of nerve fibers on ventral and lateral surface of medulla. Spinal cord elongated oval in transverse section. Canal wide. Roof plate thin, well defined. Ganglia larger. Undifferentiated mass of cells at caudal end of spinal cord.	Optic cup shallow. Optic stalk better defined; contains small tubular lumen which connects third ventricle of brain and cavity of optic vesicle. Lens consists of spherical mass of cells arranged radially; still in connection with ectoderm and containing cavity.	Vesicle pear-shaped, smaller end dorsal, detached from ectoderm. Anlage of ductus endolymphaticus as short dorsal evagination. Thin layer of mesenchyma between vesicle and ectoderm, also between vesicle and hind brain.

Nose	Hypophysis	Mouth	Digestive System, Liver, Pancreas, Spleen	Gills, Thyroid, Thymus, Trachea, Lung	Urino-genital System	Heart and Blood Vessels	Skin	Stage
								19
							Single layer of long flat cells containing coarse yolk granules.	19a
Anlage of nasal organ as thickening of internal layer of ectoderm.	Anlage of hypophysis as a long wedge-shaped mass of cells the inner end of which is 2 or 3 layers thick, outer end a single layer continuous with deeper layer of ectoderm. No capsule. Lies some distance from anterior end of notochord. Wall closely applied to single-layered wall of infundibulum. Yolk granules less numerous than in underlying entoderm.	Position of mouth indicated by thickening of ectoderm.	Gut extends from level of posterior portion of eyes to a point slightly beyond posterior end of embryo. Distended anteriorly to form branchial chamber: short postanal gut.	Anlage of thyroid as median outgrowth in anterior portion of floor of branchial cavity, in close relation to hyomandibular arch. No external indications of gill arches.	Pronephric ducts present as two short straight tubes.	Anlage of heart in form of a rod of cells lying below the pharynx and between the ventral borders of the pericardial cavities.	Thickened greatly over head. Over body long flat cells interspersed with many large oval cells.	20
Thickening of internal layer of ectoderm more pronounced and more definitely circumscribed.			Anlage of liver.	Thyroid evagination deeper. Outgrowth longer. Mandibular hyoid and common anlage of third, fourth and fifth arches visible externally.				21
Slight concavity in surface of ectoderm. Thickness of wall of nasal organ equal to that of wall of forebrain. Narrow layer of mesenchyma between nasal organ and forebrain. External layer of ectoderm can be traced only to margin of nasal organ.	Mass of cells close under infundibulum, 4—5 cell layers thick. Slight indications of cavity. Has lost connection with ectoderm.	Surface invagination a broad transverse groove.	Gut extends from anlage of mouth to junction of tail end of embryo with yolk; here it runs ventrad and extends somewhat further over the yolk than in the preceding stage. Extends laterally far beyond bounds of embryo at level of anterior portion of yolk. Diverticulum of gut just behind liver extends ventrally half way to ventral surface. Pharyngeal chamber large. Midgut narrow dorso-ventrally, wide laterally. No distinction between midgut and hindgut. Wall of pharynx and dorsal wall of midgut consist of single layer of columnar cells, heavily laden with yolk granules. Ventral wall of midgut irregular yolk cells. Liver pear-shaped evagination.	Mandibular, hyoid, first branchial and common anlage of fourth and fifth arches visible externally.	Pronephric ducts coiled, open anteriorly. End posteriorly about 10" or 11" segment. End in mass of mesoderm in close proximity to entoderm.	Pericardial cavity large. Heart has become a tube. Endothelium distinct. Division into auricular and ventricular portion recognizable. Lateral blood vessels appearing, also branchial arches and sinus venosus.	Thickened over fore and mid brain.	22

Stage	Series	Length	Age	Body-form	Somites	Notochord	Nervous System	Eye	Ear
23	111 Trans. 112 Sag. 113 Front.	10 mm	24 days 22 hrs.	Head more elevated. Optic vesicles prominent. Embryo less curved ventrally and laterally. Tail end enlarged, becoming free from yolk. Yolk becoming oval in outline. Marked cephalic flexure.	Externally 23 to 24 pairs of myotomes. Muscle plate much wider laterally, extends further ventrally. Myocoele small.	Sheath well defined, a single layer of cells. Vacuolated throughout excepting a small portion at posterior end. Hypochorda well defined.	Flexure in mid brain more pronounced. Cerebral hemispheres better defined. Neuromeres in medulla well marked. Paraphysis indicated as thickening in epithelium. Spinal cord oval in transverse section. Layer of fibres well defined in ventrolateral portion of cord. Spinal ganglia better defined. Many nerve fibers beginning to grow out from ganglion cells.	Optic cup concave; outer pigment wall a single layer of cells; inner wall or retinal layer thick. Inner ends of cells becoming clear. Optic stalk narrower. Lens spherical, hollow, not completely detached from inner layer of ectoderm. Mesoderm extending between lens and wall of cup.	Vesicle pear-shaped. Ductus endolymphaticus better developed.
24	116 Trans. 117 Front.	11 mm	26 days	Outline of body straighter. Anterior limb buds indicated. Yolk pear-shaped. Heart prominent.	Externally 26 to 27 myotomes. In anterior trunk region muscle plate and cutis plate further differentiated; muscle plate extends ventrally to level of lower margin of notochord. Myocoele nearly obliterated. Septa between myotomes forming by ingrowing mesenchyma.	Extent as above. Separated from neural tube by mesenchyma throughout head and trunk. Separated from gut by mesenchyma and dorsal aorta. Hypochorda better defined.	Epiphysis better defined; paraphysis a slight evagination; walls of both a single layer of cells. Velum transversum also a single layer of cells.	Optic cup more concave, cavity very small. Lens detached from ectoderm; inner wall thicker than outer. No cellular elements in cavity of lens. Mesoderm also extending between lens and optic cup.	Vesicle pear-shaped; lateral portion of wall thinner, inner portion thick, ventral portion very thick. Ductus endolymphaticus being constricted.
25	118 Trans. 119 Sag.	12 mm	28 days 2 hrs.	Embryo less curved dorso-ventrally and laterally. Head end free to anlage of heart. Tail end projects further from yolk. Marked cephalic flexure. Ends of mandibular arches near median line but still separate. Yolk changed from oval form to pear-shaped, small end anterior. Capillaries appearing in yolk.	Externally 28 to 29 myotomes (?).	Extends to level of ear anteriorly. Separated from neural tube by mesenchyma throughout entire length except at caudal end. Separated from gut by mesenchyma and dorsal aorta.	Paraphysis a well marked narrow diverticulum. Spinal cord cells still arranged radially. Layer of fibers better defined.	Pigment wall of optic cup very thin, a single layer of flat cells. Optic stalk more constricted. Lens larger, nearly fills optic cup; cavity in lens larger. Mesoderm between lens and ectoderm. A few mesoderm cells in optic cup behind lens.	
26	120 Trans. 125 Sag. 126 Front.	13 mm	30 days 8 hrs.		Externally 30 to 31 myotomes.	Extends from otic vesicle to posterior end of spinal cord. Vacuolated throughout greater portion of its extent. Separated from neural tube and gut throughout entire extent. No mesenchyma between notochord and neural tube. Separated from gut by mesenchyma and dorsal aorta. Hypochorda not present (?).	Cervical flexure well marked. Diencephalon and mesencephalon nearly at right angles to medulla. Velum transversum much deeper. Infundibulum and hypophysis larger, also optic chiasma and torus. Commissure in torus recognizable. No plexus. Diencephalon still projects in front of prosencephalon. Ganglion of trigeminal very large. Peripheral layer of fibers developed in ventral and lateral wall of mid brain. Beginning of plica rhombomesencephalica. Spinal cord oval in section, compressed laterally; canal a narrow slit. Spinal ganglia large, well developed.	Optic cup has outer margin in close contact with ectoderm. Cavity obliterated except at outer margin. Pigment wall and retinal layer as above. Lumen of optic stalk smaller. Chorioidal groove deep. Walls of lens of uniform thickness.	Vesicle flattened on mesial surface; walls of saccular portion notably thicker than remaining portion. Mesoderm separates vesicle from ectoderm, also from hind brain. Ductus longer, constricted.

Nose	Hypophysis	Mouth	Digestive System, Liver, Pancreas, Spleen	Gills, Thyroid, Thymus, Trachea, Lung	Urino-genital System	Heart and Blood Vessels	Skin	Skeleton	Limbs	Stage
Disk-like depression on surface deeper. Nasal epithelium thicker, separated from fore-brain by thin layer of mesenchyma.				Gill bearing arches recognizable as divisions in a common enlargement from which they develop. Anlage of external gills as slight proliferations. Anlage of trachea as longitudinal groove in median line of thickened ventral wall of oesophagus. Gill clefts indicated by deep evaginations of pharyngeal and corresponding invagination of surface ectoderm. No ectodermal invagination between fourth and fifth arches.	Pronephric duct much coiled at anterior end; same caliber throughout; widely open anteriorly into coelom; posteriorly open into cloaca. No trace of mesonephros.	Heart somewhat twisted. Endothelium and mesothelium defined. Blood vessels present in anterior branchial arches. Truncus arteriosus formed. Beginnings of vitelline veins as irregular spaces on ventral surface of yolk. Anterior and posterior cardinal veins forming. Blood capillaries appearing over surface of yolk. No blood vessels in tail.			Anlage of anterior limbs visible.	23
Invagination deeper, cup-like. In free ends of cells forming bottom of cup, yolk is entirely absorbed leaving clear zone.	An oval loosely arranged mass of cells containing irregular cavities. Antero-ventral wall thinner than dorsal. Yolk not absorbed.			Gill bearing arches better developed. Ectodermal invagination between fourth and fifth arches. Tracheal groove deeper; wall a single layer of columnar cells.			Generally two layers. Cuticular margin well developed. Shows stratum corneum and stratum germinativum, each a single layer of cells. Many large oval cells (mucous, “Leydig” cells).			24
Nasal pit formed; organ oval in outline.		Epithelium of mouth shows as columnar layer of cells, although yolk is not absorbed in mouth cavity.	Anlage of gall bladder. Anlage of dorsal pancreas.	Gill bearing arches better defined. Gill bars prominent but no gill filaments. Pharyngeal portion of gill clefts extends two thirds distance to exterior, meeting ectodermal invaginations. Walls of clefts closely apposed.		Heart placed transversely. Large abdominal vein formed communicating with sinus venosus.			Anterior limbs more prominent. Posterior limb buds just discernible.	25
Nasal pit a short cylinder. Epithelium thicker. Clear zone at free ends of cells broader	An oval mass of cells closely applied to infundibulum. Contains cavity. Capsule beginning to be formed.			Thyroid extends backward to anterior wall of pericardium. Tracheal evagination deeper, tubular.	Pronephric tubules still widely open into coelom. Posterior portion narrower than anterior. No mesonephros.	Heart S-shaped, twisted. Auricular portion tubular. Ventricle constricted where it opens into conus. Conus and truncus not differentiated. Endothelium of ventricle and of pericardial cavity a single layer of flattened cells. Anterior and posterior cardinal veins formed. Large abdominal vein running through the liver. Beginning of portal circulation.	Cuticular margin thicker. Anlage of lateral line organs.			26

Stage	Series	Length	Age	Body Form	Somites	Notochord	Nervous System	Eye	Ear
27	127 Trans. 128 Sag. 130 Front.	14 mm	32 days 10 hrs	Trunk of embryo straight when viewed from side. Cephalic flexure still pronounced. Neck bend marked. Pronounced ventral bend in tail at level of posterior limbs. Lateral curvature pronounced. Yolk elongated, pear-shaped. Flattened on dorsal surface; large abdominal vein. Considerable pigment in trunk.	Externally 31 to 32 myotomes. In anterior trunk region myotomes much elongated dorso-ventrally, extend below level of notochord. Muscle plate covers one half distance between notochord and ectoderm. Cutis plate recognizable. Septa well differentiated, fibrillae fill one half of muscle cell.	Extent as above. Anterior end almost in contact with hypophysis, a small tract of mesenchyma intervening.	Epiphysis a small flattened vesicle; cavity in stalk obliterated. Posterior commissure indicated. Lumen in optic stalk very small. Dorsal wall of diencephalon a single layer of cells. Paraphysis and epiphysis both surrounded by mesenchyma. Plica rhombomesencephalica a deep invagination. Infundibulum larger; ventral process extending caudad, posterior wall single layer of cells, closely applied to antero-ventral wall of medulla. Cord oval in outline in cross section, ventral half narrower than dorsal. Layer of fibers on outside of ventral half well defined. Yolk granules have nearly disappeared.	Margins of optic cup are in close contact with ectoderm. Wall of retina thicker at bottom of cup, thinner at margin. Pigment layer thinner, consisting of a single layer of flat cells. Optic stalks longer, diameter smaller, lumen still present. Choroidal fissure present. Inner wall of lens thicker than outer, projecting into disk-like cavity.	Vesicle further flattened on mesial surface and elongated antero-posteriorly. Ductus elongated, narrowed and more constricted at base; extends well up on sides of medulla. External wall a single layer of flattened cells; mesial wall thinner.
28	131 Trans. 133 Sag. 134 Front.	15 mm	34 days 12 hrs.		Shows 32—34 myotomes.	Anterior end close to hypophysis, some mesenchyma intervening; posterior reaches end of spinal cord. Anterior end slightly enlarged. Yolk absorbed in central portion. Caudal end still in contact with neutral tube. Sheath better developed, not segmented. Hypochorda not present.	Velum transversum a single layer of cells. Beginning of choroid plexuses as two invaginations, one in front of paraphysis, other behind it. Posterior and anterior commissure appear. Infundibulum extended laterally. Commissura habenularis forming.	Margin of optic cup more constricted. Cavity of optic vesicle still present in margin of cup. Optic stalk smaller, longer, communicates with third ventricle by very narrow channel. Lens more completely fills optic cup; outer wall a single layer of cells; inner wall much thickened. Mesenchyma increasing between lens and ectoderm. A few scattering mesenchyma cells in optic cup. Choroidal fissure nearly closed.	Beginnings of lagena and semicircular canals.
29	135 Trans. 138 Sag. 139 Front.	16 mm	36 days 16 hrs.	Trunk and tail straight line. Neck and cephalic flexures less pronounced. Tail greatly widened dorso-ventrally at level of posterior limbs. Yolk much elongated, ventral surface convex, dorsal slightly concave in profile view. Mandibular arches strongly developed, ventral ends enlarged, not yet united. Pigment present in trunk and dorsal portion of head. Anterior limb buds prominent, posterior slight elevations.	Horizontal section shows 36—38 myotomes. In anterior trunk region muscle plate extended ventrally to level of pronephric ducts. Cutis plate obscure.	Extends almost to hypophysis, some mesenchyma intervening. Knobbed at anterior end. Greatest diameter at level of anterior margin of yolk. Vacuolated throughout except near ends. In head and trunk considerable mesenchyma between notochord and neural tube. Sheath better developed. Mesenchymal thickenings in sheath indicate beginnings of intervertebral disks.	Walls of telencephalon differentiated into three layers, an outer fibrous layer, a middle layer of loose cells, and an inner layer of more compact cells. Chiasma contains few fibers. Paraphysis widely open, pear-shaped, some lateral diverticula. Anterior and posterior choroid plexuses formed. Posterior larger and more convoluted. Anterior and posterior commissures present. Anlage of commissura habenularis. Recessus lateralis small; dorsal, lateral and median longitudinal zones well defined. Tuberculum posterius formed; contains commissure	Optic cup more constricted at margin coming in contact with lens. Retina much thickened excepting at margin where it is abruptly thinned indicating ora serrata. Pigment beginning to be formed in retina. Clear zone in retina next to vitreous. Indications of eye muscles.	

Nose	Hypophysis	Mouth	Digestive System, Liver, Pancreas, Spleen	Gills, Thyroid, Thymus, Trachea, Lung	Urinogenital System	Heart and Blood Vessels	Skin	Skeleton	Limbs	Stage
Nasal tube curves dorso-caudally. Nasal organ an elongated oval. Becoming separated from superficial ectoderm by ingrowing mesenchyma. Condensed layer of mesenchyma around organ indicates beginning of fibrous capsule.			Dorsal pancreas further evaginated. Anlage of spleen as a small mass of mesenchymal cells in dorsal mesentery of stomach.	Gill-bearing arches less prominent. Gill bars better developed. Gill filaments recognizable as slight buds. Third and fourth clefts perforate. Tracheal evagination deeper, distal end dilated, becoming pear-shaped. Wall a single layer of cells.	Pronephrostomic openings constricted.	Branchial arches all contain blood vessels.		Skull shows anlage of trabeculae in condensed mesenchyma.	Anterior limbs project dorsally. Posterior limb buds more prominent.	27
	Entirely free from foregut. Lies close against infundibulum. Surrounded by connective tissue capsule. Yolk absorbed. No trace of division into lobes. No cavity.	Sharply defined groove indicates position of mouth. Roof and floor of oral cavity clearly defined but cavity filled with yolk-bearing cells.	Walls of pharynx consist of one or two layers of flattened cells excepting posteriorly where still columnar. Oesophagus open. Stomach spindle-shaped, its walls composed of long columnar cells filled with yolk granules; surrounded by two or three layers of densely packed mesenchymal cells representing the beginnings of its muscular walls. Midgut small, dorsal wall fairly well defined, ventral wall irregular yolk cells. Cloaca a wide chamber, yolk nearly absorbed in its dorsal wall. Liver further extended laterally, consists of 15 to 20 hepatic cords separated by sinusoids. Cells heavily laden with yolk. Gall bladder small but well defined. Cystic duct and hepatic duct open in common into the wide ductus choledochus and this opens widely into the intestine.	Posterior portion of thyroid shows beginning of division into two parts. Tracheal diverticulum pear-shaped lying in mesenchyma in median line below oesophagus; cells columnar; yolk being rapidly absorbed. Just anterior to tracheal diverticulum marked thickening in ventral wall of gut.	Pronephric tubules lie opposite 2″ or 3″ somites. Mesonephros begins in 9″ segment from front and extends to 17″. Best developed anteriorly. Posteriorly not metameric.	Partition separating auricles nearly complete. Truncus arteriosus larger. Primitive aortae large. Hepatic vein very large. Blood vessels present in anterior limb buds.	Pigment appearing. Anlage of basement membrane. Sense organs developing.	Anlage of trabeculae, MECKEL's cartilage palato quadrate, basal plate, hyoid arch, 1″, 2″ and 3″ branchial arches, first basibranchial and faint indications of second basibranchial, also of occipital arches, all in condensed mesenchyma. Mandibular bars separated from each other ventrally also separated from basicranial plates. Quadrate closely applied to MECKEL's cartilage.		28
Nasal tube deeper. Nasal organ elongated oval. Condensation of mesenchyma around periphery of organ more marked.				Gill bars longer. Gill filaments beginning. Second cleft between hyoid and first branchial perforate, third cleft perforate, fourth perforate, fifth not perforate. Anlage of thymus as proliferations of epithelium of dorsal portions of gill arches. Tracheal evagination longer more dilated at distal end. Anlagen of lungs as lateral diverticula of distal end of trachea. Dorsal wall of trachea thicker than ventral.		Auricle small and nearly spherical; lies just dorso-cephalad from ventricle. Ventricle turned to the right. Constriction indicates valves between auricle and ventricle. Sinus venosus very large; it receives ductus Cuvieri, posterior cardinals and pronephric branch; also vein formed by internal and external jugulars. Vitelline vein very large; enters liver. Abdominal vein large, passes through liver, joins hepatic vein and other veins to form hepatic portal system, then enters sinus venosus. Large vessel on either side. Small vessels in posterior limbs. Vessels around nose and eye; also in pia mater. Dorsal aorta formed. Also subclavian and brachial arteries.		Cartilage appearing around outer portion of otic capsule.	Anterior limbs better developed; directed dorsally. Posterior limb buds slight elevations; long axis in horizontal plane.	29

Stage	Series	Length	Age	Body Form	Somites	Notochord	Nervous System	Eye	Ear
30	140 Trans. 144 Sag. 145 Front.	17 mm	38 days		Horizontal section shows 40—42 myotomes.	Yolk not absorbed in anterior end. Vacuolated throughout. Mesenchyma between anterior end and hypophysis. Posteriorly rests against neural tube. Not segmented. Beginnings of neural arches in cartilages.	Plexuses much less marked. Anterior end of brain formed by hemispheres. Paraphysis well developed; plexus extends into lateral ventricles and diencephalon. Lamina terminalis thick. Anterior commissure well defined, also commissura habenularis. Lamina cerebellaris recognizable. Ganglion of trigeminal divided into two parts. Spinal cord rounder; canal shorter dorso-ventrally. Ganglia very large; nerve roots well developed; nerve fibers appearing in ventral nerve roots. Anlage of pia mater.	Optic cup flattened laterally, surrounded, except on outer surface, by condensed mesenchyma. Retina divided into two layers; contains some pigment. Anlage of iris present. Optic stalk smaller, cavity very small. Lens larger, spherical, inner wall fills cavity except narrow cleft. Anterior wall a single layer of cells. Lens fibers forming.	Ear more extended antero-posteriorly. Utriculo-saccular partition beginning. Ductus endolymphaticus extends over lateral margins of medulla toward median line; dilated at distal end to form saccus. Anlagen of lagena and semicircular canals. Periotic capsule forming in condensed mesenchyma.
31	147 Trans. 156 Sag. 157 Front.	18 mm	40 days 20 hrs.	Trunk and tail slightly concave in profile. Cervical flexure still present. Cephalic flexure less marked. Tail very wide dorso-ventrally. Yolk more elongated, convex on ventral surface, slightly concave on dorsal margin. Pigmentation more pronounced. Mandibular arches coalesced. Boundaries of other arches no longer visible.	Horizontal section shows 44—46 myotomes.	Dorso-ventrally compressed. Yolk granules still present in peripheral portion. Neural arches better developed anteriorly.	Spinal cord shows well defined layer of fibers entirely around it. Layer is thicker in ventral half, thin on dorsal portion. Transverse diameter of cord greater than dorso-ventral. Around central canal a layer of cells radiates from canal. Nerve fibers numerous in ventral roots of spinal nerves.	Pigment increased in posterior layer of optic cup. Retina in three layers. Optic stalk still presents minute lumen; fibers beginning to be formed in its walls. Lens spherical; posterior wall fills entire cavity; epithelium a single layer of cuboidal cells.	Periotic capsule beginning to appear on external ventral side of ear.
32	159 Trans. 160 Sag. 162 Front.	19 mm	43 days		Horizontal section shows 48—50 myotomes.	Anterior end close to hypophysis; slightly knobbed. Portion anterior to heart much smaller than remaining portion; greatly enlarged at level of anterior margin of yolk. Segmentation well marked excepting in caudal portion. Neural arches in anterior trunk region extend dorsally to level of middle of spinal cord.	Three layers well defined in walls of fore brain. Epiphysis a large oval vesicle with thin dorsal wall; communication into third ventricle nearly cut off. Walls of paraphysis irregular. Choroid plexus extending into ventricles. Lateral lobes of infundibulum extended to level of mid brain. Cerebral peduncles formed in ventro-lateral walls of mesencephalon.	Optic cup flattened laterally. Ora serrata better defined. Beginnings of iris and ciliary body. Fibers in optic nerve better developed. Lens cells arranged concentrically; fibers numerous; marked chromatolysis in central portion.	Periotic capsule extends further dorso-mesially.
33	164 Trans. 173 Sag. 174 Front.	20 mm	46 days 2 hrs.	Cephalic flexure reduced. Axis of tail coincides exactly with axis of trunk. Yolk reduced dorso-ventrally, more elongated, more pointed at anterior end. Dorsal and ventral surfaces convex. Pigment better developed.	Horizontal section shows some 50—55 myotomes. In anterior trunk region muscle plate wider, extending ventrally over dorso-lateral margins of yolk. Septa thicker. Two thirds of myoblast fibrillated.	At level of anterior limbs notochord is much larger than spinal cord, at level of posterior limbs much smaller. Yolk not quite absorbed around periphery. Neural arches in anterior trunk region extend dorsally to top of spinal cord, not united; beginning in posterior trunk region; in anterior caudal region indicated in procartilage.	Olfactory nerve connected with fibrous areas in hemispheres.	Layers of retina well defined; pigment more dense. Lumen of optic stalk obliterated near brain wall; exceedingly minute distally; fibers more numerous. In center of lens nuclei have nearly disappeared. Epithelium of lens a layer of cuboidal cells. Fibers well defined, more numerous, concentrically arranged. Eye muscles better developed.	Utriculo-saccular partition extends well into vesicle. Anterior semicircular canal better developed than the others. Macula acustica sacculi well defined. Periotic capsule surrounds ear except mesial surface.

Nose	Hypophysis	Mouth	Digestive System, Liver, Pancreas, Spleen	Gill, Thyroid, Thymus, Trachea, Lung	Urinogenital System	Heart and Blood Vessels	Skin	Skeleton	Limbs	Stage
Nasal organ connected with surface ectoderm by short stalk. Clear zone in cells much wider. Organ nearly in contact with cerebral hemispheres, separated only by a very thin layer of mesenchyma. Fibrous capsule denser. Tube much longer; narrowed along distal half; stalk extends dorso-caudally; body extends directly caudally. Ventral portion of wall 1/4 thickness of dorsal.	A solid mass of cells; detached from ectoderm.	Mouth not yet broken through. Cavity well defined but filled with yolk-bearing cells.	Oesophagus occluded. Liver lies for most part on right side of body. Tubules widely separated by sinusoids. Spleen consists of two masses of cells one lying on each side of mesentery.	Gill filaments more prominent. Division of thyroid deeper making two lines of cells at distal portions. Anterior thymus beginning to be detached from gill arches. Distal portion of tracheal evagination lying closely against ventro-mesial portion of anterior end of stomach. Anlagen of right and left lungs in form of tubular evaginations lying in mesenchyma below lateral margins of oesophagus. Tubes extend caudally to level of posterior portion of heart.	Mesonephric tubules coiled. Open into pronephric duct.	Beginnings of trabeculae in ventricle.	Thickened to 4 layers over head. Glands and sense cells developed. Few pigment cells in epidermis.	Trabeculae extend forward to optic nerve; curved downward at anterior end; caudally, are continuous with basal plate; at level of posterior margin of ear they come together at sides of notochord and grow up on each side of medulla. Labial cartilages small, united in median line. Anlage of second basibranchial. Earliest traces of ossification in base of skull. Layer of condensed mesenchyma around nasal pits. Otic capsule extending mesially over dorsal and ventral surface of ear.	Anterior and posterior limbs short stumps.	30
First indications of olfactory nerve.			Evaginations in wall of stomach indicate beginning of glands. Gall bladder shows as well defined vesicle with columnar epithelial walls.	Gill bars much elongated. Gill filaments better developed. Lungs show now as pair of lateral tubular diverticula; epithelium low columnar, nuclei occupying peripheral position. Anlage of pleura as layer of cuboidal cells. Some mesenchyma between lungs and oesophagus.	Distal ends mesonephric tubules have walls thinner and infolded. Ureters very small.		Cells of corium slightly flattened.	Walls of otic capsule chondrified except on median and dorsal sides. Neurapophyses appearing in anterior portion of trunk region. Pectoral girdle chondrified; narrow scapular portion extending to level of notochord; larger ventral portion (coracoid) about half as long as scapular. Humerus chondrified; radius and ulna in procartilage.	Anterior limbs 1 mm long; project dorso-caudally. Posterior limbs .5 mm long.	31
		Mouth a deep transverse groove. Cavity still filled with cells.	Lumen of stomach sharply marked. Epithelium long columnar cells, still laden with yolk granules. Muscular walls beginning to be formed. Yolk nearly absorbed in posterior end of cloacal walls. Liver further developed; contains larger number of tubules more compactly arranged. Sinusoids smaller. Gall bladder larger and better defined. Cystic duct and ductus choledochus formed. Dorsal pancreas narrower, its lumen, where it enters gut, constricted to form a duct. Anlagen of ventral pancreases appear as dorso-lateral evaginations of ductus choledochus.	Thyroid divided into two portions which are seen in transverse sections as small groups of cells lying just dorso-laterally from the sterno-hyoid muscle. Lungs slightly longer.	Pronephros beginning to degenerate. Mesonephros extends over 8 segments, beginning with the 9th. Not segmentally arranged. 15 tubules.		Earliest skin glands in mid dorsal region. Sense organs developed.	Beginning differentiation of hypohyal and ceratohyal, also of first hypobranchial and ceratobranchial. Second basibranchial developed. Antorbital process formed. Condensed mesenchyma indicates position of inner nasal plate. Anterior ends of MECKEL's cartilage united by procartilage; also lateral margins of posterior arches. Occipital processes fused with wall of otic capsule.		32
Organ further elongated caudally. Depressions forming around exterior indicating beginning of lobulation. Capsule not so well defined as in preceding stage. Organ connected with anterior end of foregut by a solid cord of cells. Pigment beginning to grow around stalk. Olfactory nerve in connection with brain.	Greatly elongated transversely.	Groove deeper. Anlage of teeth. Anlage of tongue.	Boundary between stomach and intestine sharply marked owing to greater absorption of yolk in epithelium of stomach and formation of muscular wall of stomach. Intestine now much coiled. Cloaca differentiated from intestine by greater absorption of yolk. Oesophagus occluded. Faint sacculations indicate beginning of glands in wall of stomach. Hepatic cords widely scattered, separated by large sinusoids. Cells filled with yolk granules. Gall bladder small, lined with columnar epithelium. Empties by cystic duct into ductus choledochus. Dorsal pancreas well differentiated; duct larger except where it enters intestine. Ventral pancreases contain few tubules. Their two short ducts join cystic duct as it emerges from liver to enter ductus choledochus.	Gills longer; many filaments. Thymus, first and second portions detached from gill arches, third still connected. Lungs longer, further evaginated, lumina larger. Epithelium low columnar, heavily laden with yolk granules. Tips reach nearly to level of anterior margin of liver.	Pronephric tubules still open into coelom. Anlage of bladder as slight evagination of ventral wall of cloaca.	Auricles beginning to show bilobed condition. Walls of ventricle very thin; very few trabeculae.	Skin glands in dorsal region well developed. Corium cells flattened. Basement membrane formed.	No cartilage in pelvic girdle. Anlage of neurapophysis throughout trunk region, none in tail. Neural arches in anterior portion extend dorsally to top of spinal cord; not united. Caudally neural arches indicated in procartilage. Ossification beginning around extremities of MECKEL's cartilage.	Anterior limbs project caudally; anlage of digits. Posterior limb buds pointing caudally.	33

Stage	Series	Length	Age	Body Form	Somites	Notochord	Nervous System	Eye	Ear
34	175 Trans. 180 Sag. 181 Front.	21 mm	49 days	Axis of head, trunk and tail coincide with line slightly arched upward over yolk. Yolk elongated, narrowed dorso-ventrally; narrowest portion anterior; viewed from above pear-shaped, narrow end anterior. Tail very wide dorso-ventrally. Irregular band of pigment along side of body. Anterior limbs project postero-ventrally three digits formed. Posterior limbs project caudad.		Caudal portion filamentous with slight knob at extreme end; still rests against neural tube. Mesenchymal thickenings in sheath present in caudal portion.	Flexures less marked. Hemispheres extend far in front of diencephalon. Epiphysis and paraphysis large. Plica rhombomesencephalica well defined. Lamina cerebellaris short; commissura superior and posterior and habenularis all well developed. Spinal ganglia very large. Nerves well developed.	Ganglionic layers of retina marked off from inner layer; layer of rods and cones indicated by layer of elongated cells. Pigment prominent in iris. Epithelium of lens flat on outer surface, cuboidal on inner.	
35	182 Trans. 183 Sag. 184 Front.	22 mm	52 days			Anterior end of notochord separated from hypophysis by thin layer of mesenchyma. Surrounded by very dense membrane. Slightly constricted at level of mesenchymal condensations indicating boundaries of vertebrae. Indications of ossification in sheath. Anlage of haemal arches in anterior portion of tail.	Paraphysis shows few lateral diverticula. Ganglion habenulare and tuberculum posterius well defined. Commissura cerebellaris formed, also commissura anterior and commissura pallii anterior. Layer of fibrous matter around cord thicker. Band of cells on dorsal border of cord larger, dorsal half of central canal nearly closed. Pia mater better defined.	Rods and cones recognizable. Iris more deeply pigmented; lies close against epithelium of lens. Optic nerve well differentiated; still contains minute lumen near eye. Anlage of cornea as single layer of mesenchymal cells.	Utriculo-saccular partition extends about half way across vesicle. Semicircular canals partially enclosed in cartilage. Periotic capsule entirely surrounds ear.
36	186 Trans. 188 Sag. 191 Front.	23 mm	55 days			Does not quite reach posterior end of neural tube. Yolk absorbed except at extreme anterior end. Sheath strongly developed. Constrictions better marked. Neural arches developed throughout body; meet dorsally in trunk region but not in tail. Ossification beginning in anterior neural arches. Haemal arches better defined in tail. Where neural processes are given off notochord is compressed laterally giving it a triangular outline in cross section.		Rods and cones better defined; outer and inner nuclear layers indicated; ganglionic layer well defined. Pigment dense in retina and iris; some pigment in choroid. Lens epithelium flatter. Sclerotic indicated in band of dense mesenchyma.	

Nose	Hypophysis	Mouth	Digestive System, Liver, Pancreas, Spleen	Gills, Thyroid, Thymus, Trachea, Lung	Urinogenital System	Heart and Blood Vessels	Skin	Skeleton	Limbs	Stage
Organ longer, becoming slightly concave on ventral surface. Further indications of lobulations.		Mouth cavity still closed.	Glands better defined. No differentiation into pyloric and cardiac glands. Liver roughly triangular in section, has extended caudally. Gall bladder still small, lining still a single layer of columnar cells filled with yolk granules. Hepatic cords more definite owing to absorption of yolk. Dorsal pancreas lumen and duct smaller. Several small tubular evaginations coming off from it. Ventral pancreas lobules not distinct. Spleen an elongated mass of cells compressed dorso-ventrally lying in mesentery just above stomach.	Gills further developed showing greater number of filaments. Gill clefts open between hyoid and first branchial arches, between first and second arches and between second and third branchial arches but fifth cleft not open. Lumina of lungs still larger. Tips of lungs reach anterior margin of liver.			Cells of stratum germinativum flattened. Glands and sense organs more numerous.	Procartilage present in pelvic girdle and in femur. Ossification in side walls of brain case, also in base. Anlage of dentale as ossified plate on external surface of MECKEL's cartilage. Beginning of angulare as thin plate of bone. Indications of mento-mandibulare. Ossification beginning in premaxilla and in quadrate.	Anterior limbs project caudo-ventrally; digits plainly defined. Posterior limb buds project caudad.	34
Nasal duct opens into pharynx on one side. Connective tissue and blood vessels extend into ventral wall giving it a much lobulated appearance; dorsal wall also slightly lobulated.		Mouth broken through.	Dorsal pancreas smaller, tubules fewer. Yolk absorbed in cells. Prozymogen granules abundant.	Trachea larger and longer. Lungs longer, caudal ends behind heart, over anterior portion of liver. Walls better defined, epithelium cuboidal. Yolk nearly all absorbed.	Glomeruli well defined. Tubules very much coiled.	Auricles further developed. Cavity of ventricle large, walls thin, many trabeculae. Walls of truncus much thicker than those of conus. Valves beginning to be formed between conus and ventricle; also between conus and truncus.		Occipital arch growing up from sides of notochord; below uniting posterior ends of parachordals. Parachordals fused with basal plates. Trace of trabecular crest to which process of quadrate is attached. Short otic process fused with otic capsule. Coracoid process extends nearly to ventral margin of liver; scapular extends to upper margin of notochord. Humerus larger; glenoid cavity very deep. Ulna and radius chondrified. Anlage of carpals and metacarpals. Pelvic girdle chondrified; consists of dorsal iliac portion and ventral pubic portion. Femur chondrified; anlagen of tibia and fibula.		35
Nasal tubes open into pharynx on both sides.		Posterior median portion of cavity still contains yolk-bearing cells. Papillae of teeth formed.	Posterior portion of liver has extended dorsally to level of posterior portion of stomach; contains few bile ducts. Cells loaded with yolk. Tubules much more compact; sinusoids narrower, changing to capillaries. Gall bladder larger, cells in wall low columnar or cuboidal, free from yolk. Dorsal pancreas 6—8 tubules. Ventral as above. Spleen larger, more vascular.	Trachea smaller, lining layer of cells flat. Lungs much farther distended laterally, extending to extreme lateral margins of the liver. Pleura consist of layer of closely apposed cuboidal cells.	Pronephric tubules reduced in size.		Glands larger; sunk below level of epidermis; contain lumen. Cells of stratum germinativum elongated flattened.	Floor of otic capsule nearly complete. Ossification beginning in parasphenoid also in parietals and frontals. Anlage of vomer. Neural arches developed throughout body; meet dorsally in trunk, not in tail. Haemapophyses appearing in anterior portion of tail. Ossification beginning in neural arches. Bone well developed around centers of vertebrae. Traces of ossification in scapula and humerus.		36

Stage	Series	Length	Age	Body Form	Somites	Notochord	Nervous System	Eye	Ear
37	192 Trans. 196 Sag. 197 Front.	24 mm	58 days			Anterior end in contact with parasphenoid but does not reach level of hypophysis. Constrictions opposite bases of neural arches more marked anteriorly. Ossification well marked around sheath. Haemal arches approximating ventrally in tail. Anlage of lateral basal process in cartilage in anterior portion of body.	Paraphysis with many lateral diverticula; still opens into third ventricle. Eminentia Pallii medialis well defined, also corpus striatum (?). Pallium and subpallium differentiated. Septum ependymale present. Beginning of taenia fornicis.		
38	198 Trans. 199 Sag. 200 Front.	25 mm	61 days	Flexures as above, yolk elongated, diameter reduced dorso-ventrally and laterally. Tail broader, less pointed. Surface more deeply pigmented; bands more marked. Both anterior and posterior limbs possess four digits. Pigment bands more sharply defined.	In anterior trunk region myotomes wider occupying four fifths of space between notochord and skin; extended ventrally to lower margin of yolk. Myoblasts in upper portion of myotome completely filled with fibrillae.	In anterior portion much compressed laterally, more compressed at bases of neural processes. At level of anterior limbs smaller than spinal cord; in trunk region and at level of posterior limbs large as cord; in tail about twice the diameter of cord. Yolk all absorbed. Haemal arches well developed, free ends coalesced. Ossification very considerable in neural arches and notochordal sheath. Lateral basal processes better developed throughout trunk region.			Ductus endolymphaticus extends over dorso-lateral walls of medulla; stalk very narrow but still widely open into sacculus. Semicircular canals better developed; all partially enclosed in cartilage. Lagena a more extended evagination. Anlagen of pars neglecta and macula acustica neglecta. Macula acustica sacculi two layers of cells thick.
39	201 Trans. 204 Sag. 205 Front.	26 mm	64 days 4 hrs.			Compressed dorso-ventrally in anterior part of body, laterally in posterior part. Anterior end surrounded by bone.	All divisions of brain clearly defined. Plexuses extending from hemispheres to medulla. Optic nerves very small, hollow near brain. Mid brain short, slightly arched. Ganglia habenulae large, symmetrical. Velum transversum contains numerous large blood vessels. Infundibulum wider than mid brain. Cerebellum extremely small. Spinal cord oval in section. White matter on outside thickest in lateral portions. Dorsal columns large, broader anteriorly. Central canal very small nearly circular in section. Some yolk granules still present in cells of cord. Pia mater well developed.	Eye not so much flattened laterally. Retina shows layer of rods and cones, outer nuclear layer, outer reticular layer, inner reticular layer, ganglionic layer. External limiting membrane well defined. Choroid better differentiated; pigment layer closely apposed to pigmented layer of retina. Lens spherical, surrounded by a capsule of a single layer of flattened cells. Fibers well developed. No nuclei in center. Posterior chamber contains a few mesenchymal cells. Corneal epithelium in two layers. Eye muscles well developed.	

Nose	Hypophysis	Mouth	Digestive System, Liver, Pancreas, Spleen	Gills, Thyroid, Thymus, Trachea, Lung	Urino-genital System	Heart and Blood Vessels	Skin	Skeleton	Limbs	Stage
Wall of nasal duct consists of two layers of cuboidal cells.	Lies against floor of skull surrounded by a connective tissue capsule. More lobulated. Blood vessels growing into it.	Entire mouth open. Oesophagus open. Teeth projecting slightly into mouth cavity, ossified. Tongue better developed.	Glands in stomach well formed. In anterior half numerous, flask-shaped; in posterior half tubular. Both kinds unbranched. Yolk absorbed in epithelial cells of stomach also in hindgut; midgut cells still heavily laden. Oesophagus open. Liver extends further caudally and dorsally. Hepatic cords more closely approximated. Yolk partially absorbed. Both dorsal and ventral pancreases larger, showing greater number of tubules. Spleen lies pressed against dorsal wall of body cavity; surrounded by thin layer of connective tissue; shows numerous dividing cells; much connective tissue.	Trachea longer reaching to caudal region of heart before dividing. Lungs longer, walls better defined, still very thick. Caudal ends detached from intestinal wall except for short thin mesentery. Epithelium becoming flattened. Mesenchyma less compact. Lungs extend over anterior two thirds of liver laterally to dorso-lateral margins of liver. Posteriorly attached by band of mesenchyma to lateral margins of wall of stomach.	Pronephros reduced in size. Tubules cut off from coelom? Duct (ureter) opens into cloaca. Mesonephric tubules greatly convoluted; extends from 9″ to 17″ somite. Bladder comes off from cloaca near point where ureters enter. Sexual cells, a single row of cells containing large yolk granules. Opposite 15″ segment.		Glands appearing in ventral region, anteriorly and posteriorly; numerous in lateral portion. Sense organs more numerous.	Supra-scapula well formed in cartilage extending dorsally to level of spinal cord. Tibia and fibula chondrified; no tarsals or metatarsals. Ilium and pubis larger. Mesenchyme around nasal pits. Ossification beginning around margin of trabeculae. Parasphenoids forming as long plates on lower margin of basal plates extending forward to region of eye. Vomer ossified. Frontal ossified at sides and posterior end. Neural spines beginning to appear anteriorly. Indications of ossification in femur. Ossification beginning in neural processes and in haemal arches.		37
			Yolk nearly absorbed in liver.	Gills more prominent; filaments much branched. All clefts perforate excepting fifth. Lateral portion of thyroid contains small irregular vessels. Pleura proximally layer of flattened cells. Some mesenchyma between pleura and epithelium of lungs.			Oval cells and sense organs more numerous. Sensory hairs evident. Stratum corneum very flat cells. Stratum germinativum two layers.	Basilar plate continuous with capsular floor and trabeculae. Jugular foramen formed, elongated. Otic process of quadrate united with otic capsule. Antorbital process further developed. Haemapophyses well developed; not united ventrally. Ossification in phalanges of anterior limb, also in iliac process.	Limbs better defined; anterior reach ventrally to border of yolk. Digits better defined in both.	38
Antero-lateral wall very thin. Lobulations prominent. Epithelium of dorsal wall ciliated. Olfactory nerve clearly defined.	Enlarged transversely. Divided into two portions composed of cells of different staining capacity, anterior part more deeply stained. Posterior part more lobulated and more vascular.	Unicellular glands in epithelium of mouth and tongue. Teeth extending into mouth cavity. Tongue well defined.	Unicellular glands present in mouth, pharynx, oesophagus and hindgut. Extreme anterior portion of stomach contains no glands. Pyloric glands much branched. Intestine lies in 4 to 5 transverse coils. Cavity of small intestine widely open. Muscular walls better developed. Epithelium consists of single layer of long columnar yolk-laden cells. Hindgut larger; yolk absorbed; anterior part shows evaginations (glands of LIEBERKÜHN?). Liver lies closely in contact with dorsal wall of coelomic cavity. Yolk all absorbed. Gall bladder very large, surrounded by a layer of connective tissue, epithelium flat. Dorsal pancreas has grown caudally and contains 50 or more tubules; ventral contains about 12 tubules, is about $^1/_3$ size of dorsal. Ducts of both lined with cubical epithelium.	Thymus consists of three spherical epithelial patches on each side. Two lie close together opposite posterior portion of ear. Anterior largest; posterior much the smallest. Trachea much larger, walls thinner, epithelium flatter. Lungs much larger, tapering caudally to end at level of posterior limbs; are attached to intestinal wall and to liver by short mesentery. Left lung larger than right and extends further caudad.	Pronephros degenerating. Extends from middle of 3″ segment to middle of 4″, hanging down into body cavity. Duct very small. No openings into body cavity discernible. Mesonephros extends from 15″ to 20″ segments. Ducts open into cloaca. Bladder oval, thick-walled, much folded, opening into cloaca by short urethra, surrounded by connective tissue. Sexual glands two rods of large oval cells extending from 13″ to 18″ segment, just ventrad of mesonephros.	Auricles nearly same size in transverse section. Sinus venosus very large. Truncus arteriosus divided longitudinally. Trabeculae appearing in walls of auricles. Marked constriction between sinus and auricles.	Skin glands present in abdominal region. Stratum corneum a layer of squamous cells. Basement membrane dense.	Internasal cartilage connects trabeculae anteriorly. Pubic bones united in median line. Tarsals and metatarsals chondrified. Palatopterygoid and sphenoid ossified in posterior portion.		39

Stage	Series	Length	Age	Body Form	Somites	Notochord	Nervous System	Eye	Ear
40	206 Trans. 207 Sag. 209 Front.	27 mm	67 days			Chorda more compressed laterally at points where neural arches come in contact. In trunk region and in region of posterior limbs transverse diameter equals that of spinal cord; in tail region diameter twice as great as that of cord. Beginning ossification in haemal arches.			Ear much extended antero-posteriorly compressed dorsoventrally. Ossification beginning in external portion of otic capsule.
41	210 Trans. 211 Sag. 212 Front.	28 mm	70 days 4 hrs.	General coutour of body much changed, owing to rapid absorption of yolk. Tail broader dorsoventrally. Constricted at level of posterior limbs. Yolk very long oval, flatter on ventral surface. Pigmentation extending down over one half of lateral surface of yolk.					
42	213 Trans. 214 Sag. 216 Front.	29 mm	74 days 12 hrs.						
43	217 Trans. 218 Sag. 219 Front.	30 mm	78 days		In anterior trunk region myotomes wider occupying nine tenths of space between notochord and skin; extend ventrally to median line where they coalesce.	Much constricted in region where cartilages are in contact with body of vertebrae. Thickenings of sheath to form intervertebral disks better marked. Cartilages lie between layer of bone and sheath. Ossification beginning in lateral basal processes. Cartilaginous ribs present.	Brain and cord nearly in straight line. Groove present between diencephalon and mesencephalon. Deep groove in front of cerebellum. Plexuses large filling greater portion of 3rd ventricle extending into lateral ventricles and into 4th ventricle. Distal end of paraphysis lies on level with epiphysis. All commissures better defined. Brain fills brain case at anterior end, not posteriorly. Spinal cord does not nearly fill canal. Dorsal columns of cord well defined; gray commissure present between them and gray matter of cord. Central canal very small, circular in section.		Endolymphatic sac wider; duct narrower. Cristae acusticae of canals formed. Macula acustica sacculi a thickened area of epithelium three rows deep. Semicircular canals enclosed in cartilage. Ossification more extended on lateral surface of periotic capsule.

Nose	Hypophysis	Mouth	Digestive System, Liver, Pancreas, Spleen	Gills, Thyroid, Thymus, Trachea, Lung	Urino-genital System	Heart and Blood Vessels	Skin	Skeleton	Limbs	Stage
			Intestine crosses abdominal cavity 6—7 times. Dorsal portion of liver connected by narrow band with ventral portion. Hepatic cords closer together. Few hepatic ducts. Dorsal and ventral pancreases not in contact yet. Tubules more numerous in dorsal.	Lungs reach to level of caudal end of liver.			Unicellular gland and sense organs very numerous. Sensory hairs projecting beyond surface.	Ossification beginning in haemal arches.		40
				Walls of trachea and lungs very thin; surrounded by mass of mesenchyma. Lungs flattened against stomach. Epithelium thinner; pleural covering very thin.				Ossification well defined in haemal arches.		41
			Caudal portion of liver occupies over one half of coelomic cavity. Numerous hepatic ducts. Dorsal and ventral pancreases in contact. Dorsal much the larger. Spleen longer; compressed dorso-ventrally between intestine and dorsal body wall. Connective tissue more abundant.	Gills better developed, pigmented. Filaments greatly increased in number. Second, third and fourth gill clefts widely open to exterior; first and fifth imperforate.					Limbs longer, pigmented, both pairs functional. Four digits well defined on each.	42
		Under lip marked by a very deep transverse groove. No upper lip. Tongue being cut off on ventral surface by deep lateral constriction.	Extreme anterior end of stomach contains no glands except unicellular. In anterior portion flask-shaped glands are larger and more numerous. Middle and posterior portion contains branched tubular glands. Intestinal epithelium better defined; still contains yolk granules. Hindgut contains branched glands. Long process of liver extending posterior to gall bladder; another in median line extending over dorsal wall of gut.	Right lung lies against margin of liver; caudal end in contact with spleen.	Pronephric ducts small but still open. Mesonephros begins 3 or 4 segments behind pronephros and extends over about 10 segments. Bladder epithelium short columnar cells, enclosed in connective tissue. Walls much folded. Sexual glands extend from 14" to 20" segments. Yolk granules present in posterior portion.	Pericardium well defined, very thin, detached from muscular wall. Auricles widely in communication with each other. Blood passes into ventricle by single opening on left side. Valves present in this opening. Semilunar valves between ventricle and conus appear as extended proliferations of wall. Valves also present between conus and truncus.	Mucous glands larger, abundant, none on ventral surface. Unicellular glands more numerous.	All the cartilages of carpus and tarsus metacarpus and metatarsus and phalanges formed. Middle portion of MECKEL's cartilage surrounded by bone. Premaxillae and frontals well ossified. Cartilage appearing in center of body of vertebrae.		43

Stage	Series	Length	Age	Body Form	Somites	Notochord	Nervous System	Eye	Ear
44	220 Trans. 221 Sag. 223 Front.	31 mm	82 days 12 hrs.						
45	224 Trans. 225 Sag. 226 Front.	32 mm	87 days			In caudal region larger than spinal cord. More constricted in centers of vertebrae. Intervertebral cartilages more prominent. Layer of bone thicker.			
46	227 Trans. 229 Sag. 230 Front.	33 mm	92 days						
47	231 Trans. 232 Sag.	34 mm	97 days	General form of body resembles adult. Ventral surface of head and trunk nearly in straight line. Anterior and posterior limbs project far below ventral surface of body. Pigmentation bands more precisely marked. Dorsal median dark band, below this a light band, then a broad dark band.		Bone surrounding anterior end thicker. Ribs better developed; extend one half of distance to lateral surface of body. Neural arches at base more completely ossified.			

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			Liver still larger in caudal portion occupying $^{3}/_{4}$ of body cavity. Has several hepatic ducts entering cystic duct. Gall bladder removed some distance from ventral pancreas. Dorsal and ventral pancreases have united into a continuous mass.	Tip of lung at caudal end of liver. Dorsal walls of lungs in region anterior to liver very much thinner than ventral wall.						44
	Compressed anteriorly between infundibulum and floor of skull; broader posteriorly. Much lobulated.		Lumen of intestine larger; epithelium a single layer of poorly defined cells. Muscular wall very thin, a single layer of cells. Few hepatic ducts seen in body of liver; a few enter the cystic duct. Dorsal pancreas tubules compactly arranged.	Lungs very much larger, owing to thinness of walls very much collapsed. Tips of lungs still show embryonic condition. Cartilages formed in walls of trachea. Epithelium of lateral walls of trachea much thicker than dorsal and ventral walls. Trachea in anterior portion shows columnar cells; ciliated? At level of heart epithelium flat.	Pronephros compressed dorso-ventrally; extends over one segment. Mesonephros extends over about 10 segments.		Unicellular glands extremely numerous.			45
			Posterior portion of liver divided by transverse fissure into smaller dorsal and larger ventral portion. Gall bladder very large; extends far caudal of liver; lined with flattened epithelium. Cystic duct larger and longer. Pancreas large extending around dorsal and lateral portion of intestine. Ducts open into cystic duct; show numerous branches with tubules emptying into them. Spleen larger, more vascular.		Sexual glands extend far forward; begin to project down into body cavity; more distinctly separated from mesonephros.					46
			Intestine forms 6 or 7 transverse folds. Intestinal cavity very large. Muscular wall of midgut consists of two or more layers of cells. In hindgut unicellular glands very numerous. Dorsal and ventral pancreases more intimately united; dorsal larger and contains greater number of tubules. Spleen lies just to left of median line in concavity in dorsal wall of stomach.	Tracheal cartilages better developed at anterior end. Lungs on either side of stomach. Walls irregularly folded. Left lung still notably shorter than right and lying nearer mesial plane of body.	Pronephros smaller; lumina of many tubules obliterated; duct degenerating. Mesonephros extends from 9'' or 10'' segment over about 13 segments. Müllerian duct not formed yet.			Scapula flattened laterally, broad antero-posteriorly. Coracoids meet in mid-ventral line. Ossification beginning in pectoral and pelvic girdles, also in humerus and femur. Sphenoid ossified. Parietals ossified in median portion. Opisthoticum ossifying, also occipital arch.	Limbs much longer. Digits longer.	47

Stage	Series	Length	Age	Body Form	Somites	Notochord	Nervous System	Eye	Ear
48	233 Sag.	36 mm	110 days			Anterior end at level of hypophysis, sometimes beyond it. Intervertebral cartilages thicker. Bodies of vertebrae more constricted. Layer of bone around cord thicker.			
48 a		38 mm							
49	234 Trans. 236 Sag. 237 Front.	39 mm	126 days	Has practically reached adult condition except in coloration. Same bands prominent as in preceding stage. Lateral band mottled.		Ossification very complete in neural spines and basal processes in ribs, and in haemal arches; beginning in haemal spines.		Eye nearly spherical, slightly flattened laterally. Retina as in 26 mm excepting ganglionic layer is one cell thick. Other layers together with external and internal limiting membrane sharply defined. Iris, choroid, cornea and sclerotic as in 26 mm. Lens capsule cells much more elongated tangentially.	

Nose	Hypophysis	Mouth	Digestive System, Liver, Pancreas, Spleen	Gills, Thyroid, Thymus, Trachea, Lung	Urino-genital System	Heart and Blood Vessels	Skin	Skeleton	Limbs	Stage
			Epithelium of pharynx consists of 2 or 3 layers of flat cells containing numerous unicellular glands. Oesophagus thrown into numerous longitudinal folds; epithelium columnar, ciliated, with unicellular glands. Muscular wall very thin. Liver very large. Lies on right side. In frontal section outline is long triangle, in transverse section an equilateral triangle. Posterior end shows several irregular processes. Pancreas elongated cephalo-caudally. Anterior portion flattened and closely applied to dorso-mesial wall of intestine. Posteriorly greatly thickened and roughly triangular in shape. Posterior end lies on right side.							48
			Anterior wall of stomach thin; circular band of muscular fibers very thin, increasing in thickness toward pylorus. Epithelium columnar. Submucosa developed. Extreme anterior end free from glands. Flask-shaped glands confined to anterior portion. Enlarged part of glands consists of a single layer of very flat cells; duct, cuboidal or columnar. Middle and posterior portion of stomach contains branched tubular glands. In pyloric portion epithelium is thrown into longitudinal folds. Inner ends of cells form a striated border which extends into intestine. Liver contains numerous bile ducts. Hepatic cords well defined. Highly vascular.							48 a
	Compressed; extended laterally. Contains many tubules.	Teeth project far into mouth cavity. Tongue narrower in front. Taste buds well developed in epithelium of tongue.	Intestine shows strong circular and longitudinal bands. Walls thrown into longitudinal folds. Lumen greatly expanded at level of posterior limbs forming rectum? Epithelium columnar. Unicellular glands more numerous posteriorly. Gall bladder large oval, extends caudally beyond liver. Walls formed of a single layer of flat cells. Cystic duct large. Pancreas composed of branched tubules. Dorsal portion opens by a single duct just caudally of stomach: ventral portion smaller, opens by two ducts. Spleen lies on left side, in frontal or sagittal section long, oval pointed in front. Arrangement of cells suggesting tubules.	Gills all developed. Second, third and fourth arches perforate, first and fifth not broken through. Thyroid small, halves widely separated; consists of 20—30 large vesicles. Lies close against first epibranchial. Many vesicles filled with colloidal material. Trachea at caudal end much larger than oesophagus. Divides at level of glenoid cavity. Lungs much longer extending some distance behind liver. Right lung larger than left and extends further caudad. Epithelium very thin and flat.	Pronephros degenerating. Lumina of many tubules obliterated. Duct degenerating. Mesonephros extends from 9" or 10" segment over about 13 segments. Müllerian duct not formed. Bladder large, wide transversely, thin-walled, extending well forward beyond pelvis. Sexual glands nearly coextensive with mesonephros.	Heart well developed. Auricles well defined folded over ventricle. Imperfect ventricular septum. Ventricle with numerous muscular trabeculae. Truncus arteriosus thick walled: conus thin. Branchial arteries well developed. Pulmonary arteries and veins very small. Hepatic veins very large; they unite to form sinus venosus which empties into the right auricle. Internal and external jugulars present; jugular sinus well marked. Splenic, gastric and mesenteric veins formed. Caudal vein gives off branches to form renal portal system. Arteries and veins in limbs complete.		Internasal cartilage well defined. Lateral and dorsal wall of brain capsule now a thin layer of bone. Bone in whole extent of lower jaw. Nasal capsule formed in cartilage. Hypohyal much larger. Second hypobranchial still very small. Cartilage appearing around orbit. Membrane bones of skull generally formed. Tibia and fibula, tarsals and metatarsals ossified.		49

Some Variations in External Structures.

Before the individual variations are considered in detail it should be stated that a given nest contains but few eggs that are in precisely the same stage of development. The differences are most obvious in the early stages up to the closure of the neural fold. From the closure of the neural folds to the 39 mm larva the variations are not so pronounced, yet there are innumerable minor variations.

In the following descriptions the principal variations observed in the external features are first recorded, then those observed in the sections.

Cleavage.

In the cleavage stages, from the second on to late cleavage, there is so much variation in the position, extent and rate of progress of the various grooves that it is impossible to record them. Some of the variations have been described elsewhere (1904 b) by the senior author.

Gastrulation.

Some variation is found in the position of the first line of invagination which forms the dorsal lip of the blastopore. Its first appearance may be along a line equidistant from the equator and the vegetative pole or it may form nearer the equator and again sometimes nearer the vegetative pole. The first line of invagination may be nearly straight and again it may be decidedly crescentic. The maximal diameter of the yolk plug may equal one half the diameter of the egg. The closure of the blastopore usually occurs in about six days but it may close in five days.

Closure of neural folds.

Variations in the closure of the neural fold are frequently observed. The coalescence of the lateral portions of the fold usually begins at the posterior end. Sometimes they first coalesce along the middle portion of the embryo. Usually the transverse portion of the fold is continuous; at other times it shows a deep transverse groove which separates it into right and left halves. Cf. Figs. 18, 19, 20, 21. Wide variations exist in depth, width and extent of the neural groove.

Appearance of optic vesicles.

The optic vesicles are usually present before the complete closure of the neural fold. Sometimes they are present as disc-like depressions in the neural plate before the lateral portions of the fold have begun to coalesce; again, but rarely, they are not visible until the folds have closed.

Neuromeres (?).

There are frequently observed in the cephalic region well marked serial elevations and depressions along the inner margins of the lateral folds and across the neural plate. In other embryos there is not the slightest trace of either.

Somites.

In some embryos three myotomes are differentiated before the neural folds are closed, while in others there are no traces of myotomes until the folds are closed. The number of myotomes early becomes exceedingly variable in the tail. It is here impossible to count them accurately either in surface views or in sections. In the trunk i. e. between the limbs from the 15—16 mm larva up to the 39 mm they seem to be fairly constant numbering 18—20. In the tail however they are variable, so that in larvae of identical lengths there may be a variation of 1—5 myotomes. It should be emphasized that the number in the tail is determined with great difficulty since the most caudal are but slight thickenings in the mesoderm.

Lateral curvature of body.

In the embryos of 8—15 mm there is much variation in the lateral curvature of the body. In some nests as high as 80% of the embryos have the head and tail curved to the right. Other nests show a like percentage in which the head and tail are curved to the left. Out of 328 eggs, taken from five nests, 174 had the concave side on the right and 154 on the left.

External gills.

In most embryos of 9 mm (Fig. 25) the fourth and fifth arches are a common mass with no indications of the line of division; in some the line of invagination is distinct. In the later stages (e. g. 25 mm) there are usually five or six filaments on the middle gill bar, in others there are eight or nine. This variation is even more pronounced in the 26—39 mm larvae.

Limbs.

Some variations have been noted in the time of appearance of both the anterior and the posterior limb buds. The anlage of the anterior limb is usually discernible in the 11 mm stage (Fig. 27), but sometimes not until the larva measures 12 mm. The posterior limb buds are usually beginning in the 12 mm stage, sometimes are not present until the larva measures 13 mm. In the formation of the digits variations are found. Three are usually present on the anterior limbs in the 20—21 mm larva. In some three are not present until the larva is 23 mm long. The same variation is observed in the time of formation of the fourth digit on the anterior limb. Similar variations are found in the time of formation of the posterior digits.

Pigmentation.

Although little variation is observed in the position of the bands there is much variation in the degree of pigmentation. These differences are most pronounced in the larvae between 19—25 mm. In some the chromatophores are densely aggregated while in others they are sparsely scattered. In some (25 mm) they have extended over the dorsal portion of the yolk only, while in others they have extended over one half of the lateral surface of the yolk.



Variations in Internal Structures.

In the study of the variations of internal structures only those which are most obvious have been recorded.

Notochord.

There is considerable variation in the anterior extent of the notochord in nearly all stages. This variation is more obvious in the earlier than in the later stages. Usually a considerable tract of mesenchyma lies between the anterior end of the chorda and the hypophysis. Frequently this tract is short and sometimes only a narrow band.

Eye.

In sections the optic vesicles show the same variations which have been recorded under variations in external features. The appearance of pigment in the retina and iris shows considerable variation. In the 17 mm embryo series 140, 141, 145 show considerable pigment in the retina and its first appearance in the iris, while 146 shows the beginning of pigment in the retina and none in the iris. The time of first appearance of pigment in the choroid is likewise variable. In the 18 mm embryo series 152, 155 show considerable pigment, series 146, 151 show but little pigment, while in series 147, 149, 150 there is no pigment in the choroid.

Ear.

In the 6 mm embryo, series 100, there is a cup-shaped invagination of the inner layer of the ectoderm while in series 101 there is a vesicle. In the 7 mm embryo, series 102, shows the otic vesicle just closed, while in series 103 it is not quite closed. In the 18 mm larva, series 146 and 147, the endolymphatic duct extends over the medulla to about one half the distance to median line; in series 151 it extends over the lateral margin of the medulla; in series 149 it does not extend over the lateral margin of the medulla.

Nose.

In the 9 mm stage series 106 shows the anlage of the nose as a shallow invagination of the ectoderm. In series 107 there is no invagination. In 108 it is slightly cup-shaped. In series 109 thickened ectoderm, in series 110 thickened ectoderm.

Epiphysis.

In the 9 mm stage series 106, 109, 108 show the epiphysis to be a slight cup-shaped evagination in the dorsal wall of the fore-brain. In series 107, 110 the evagination is deeper and somewhat pear-shaped.

Paraphysis.

In the 11 mm embryos, series 116, the paraphysis is a very shallow evagination in the postero-dorsal wall of the telencephalon. In 117 the paraphysis is a deep pit-like evagination.

Hypophysis.

In the 9 mm embryo, series 106, 107, the anlage of the hypophysis is two layers of cells thick, in 108 it is but a single layer, while in 109 it is three or four layers thick.

Liver.

In the 9 mm embryo, series 106, 107, 108, 110 the anlage of the liver is shown as a wide evagination of the gut; while 109 shows two or three tubules.

Pancreas.

The dorsal pancreas seems to grow very slowly and to show much variation. Series 118 and 119 show the dorsal pancreas as a slight evagination of the dorsal wall of the gut. In series 120 it is in about the same stage. In series 125 the evagination is vesicular. In the 13 mm embryo series 121, there is a cup-shaped evagination. In 122, 124 the evagination is vesicular. In the 14 mm stage it varies from cup-shaped evagination in series 127, 130 to vesicular in 129.

Spleen.

In the 15 mm embryo, series 131, 134 show the anlage of the spleen as a small mass of mesenchymal cells in the dorsal mesentery of stomach. In series 132 there is no indication of spleen. In 133 there is a well defined mass of mesenchymal cells.

Thymus.

In the 16 mm embryo, series 137, 138, 139 the thymus begins as a small mass of cells in close proximity to the 3rd branchial cleft. In 136 the thymus anlage is not yet present.

Trachea — Lungs.

In the 10 mm embryo series 111, 112 show the beginning of the trachea as a short groove in the ventral wall of the pharynx. Series 113 shows a deeper vesicular evagination.

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B. Alphabetical arrangement of authors under topics.

1. General Works.

a) Systematic.

b) Zoological.

Nussbaum 07.
Oesterdam 89.
Oken 17, 36.
Oppel 90, 96.
Osawa 99, 02.
Osborn 84.
Owen 66.
Phisalix 97, 97a.
Rabl 89.
Reese 06.
Rejsek 97.
Rudolphi 17.
Rusconi 27, 28, 37, 43, 43a.
Ryder 90.
Rusconi and Configliachi 18.
Saski 87.
Schlegel 37.
Schmidl 50.
Schmidt, Goddard en Van der Hoeven 64.
Schneider, J. G. 79.
Schneider, O. 73.
Schneider, R. 90.
Schreibers 01, 18, 20.
Siebold 28.
Smith, H. M. 98.
Smith, J. 32.
Smith, F. A. 28.
Spicer 69.
Stöhr 06.
Stricker 72.
Strube 88.
Tommasini 75.
Townsend 82.
Treviranus 20.
Vaillant 63, 63a.
Valentin 37.
Viator 37.
Wagler 28.
Wagner, F. 80.
Wagner, R. 37.
Weinzettl 81.
Weismann and Wiedersheim 78.
Whitman 85, 99.
Wiedersheim 77, 90, 09.
Wilder, B. G. 74, 83.
Wilder, H. H. 91.
Zeller, 88.

c) Embryological.

Broili 03.
Chauvin 83, 83a.
Cope 86.
Eycleshymer 02, 04, 04a.
Fülleborn 94.
Hay 88.
Kammerer 07.
Keibel 01, 06.
Kerbert 03, 04, 05.
Krainz 61.
Mc Gregor 96.
Morgan 97.
Platt 94, 96.
Rabl 98.
Schoenichen 04.
Schulze, F. E. 76.
Schulze, O. 05.
Smith, B. G. 06.
Virchow 94.
Viré 04.
Whitman 88, 88a.
Wiedersheim 77, 90.
Zeller 89, 90.

2. Earliest Stages.

Andrews 98, 98a.
Bussy 04, 05.
Camerano 83.
Eycleshymer 95, 02.
Ishikawa 03, 05.
Kerbert 03.
Lange 06, 07.
Schmidt 04.
Sobotta 97.
Whitman and Eycleshymer 96.
Zeller 90.

3. Skeleton.

Albrecht 78.
Baur 85, 88, 89, 91.
Buchs 02.
Carlson 86.
Cope 89.
Davison 97.
Dugès 34.
Field 95.
Gadow 95.
Gage 82.
Gaupp 04, 06.
Gegenbaur 62.
Göppert 95, 96.
Hay 89, 90.
Hepburn 07.
Van der Hoeven 66.
Houghton 03.
Howes and Davies 88.
Lucas 86.
Meyerhofer 09.
Mivart 70.
Murray 97.
Nussbaum 08.
Parker 68, 77, 96.
Peter 94, 98.
Platt 97.
Reynolds 97.
Ryder 79.
Schauinsland 06.
Sieglbauer 04.
Smallwood 08.
Smith, F. 00.
Terry 04.
Van Pée 03, 03a, 04.
Walter 87.
Whipple 06.
Wiedersheim 77, 92.
Wilder, H. H. 03.
Winslow 98.
Zwick 97.

4. Muscles.

Braus 07.
Davison 94.
Drüner 03.
Dugès 34.
Eycleshymer 02a, 04.
Fürbringer 06.
Gage, S. P. 90.
Göppert 94.
Humphry 72.
Macallum 87a.
Maurer 06.
Mivart 69, 69a.
Platt 97.
Ribbing 07.
Schaper 02.

5. Blood and Vascular System.

Boas 81.
Claypole 93, 96.
Crisp 60.
Eisen 99.
Favaro 06.
Gage, S. H. 85a.
Gulliver 73.
Harting 58.
Hochstetter 06.
Van der Hoeven 41, 67a.
Joseph 05.
Kneeland 68.
Knoll 96.
Königstein 03.
Kunitomo 03.
Langerhans 73.
Macallum 92.
Mandl 39, 39a.
Marcinowski 06.
Miller 00a.
Minot 98, 00.
Owen 35, 42.
Romeisen 05.
Rooy 07.
Schmidt, H. D. 78.
Sobotta 02.

Vaillant 62.
Welikij 90.
Wyman 54.
Zuckerkandl 95, 95a.

6. Respiratory System.

Böttger 76.
Bridge 00.
Camerano 83a.
Clemens 95.
Drüner 01.
Eycleshymer 06a.
Göppert 98.
Kneeland 56.
Königstein 03a.
Maurer 88, 88a.
Miller 00b, 02, 05.
Wiedersheim 77b.
Wilder, H. H. 96.
Wyman 54.

7. Digestive System.

Becker 02.
Bensley 00.
Blyer 74.
Bolau 99.
Broman 04.
Choronshitzky 97, 00.
Gage-Gage 90.
Gage, S. H. 85.
Göppert 91, 06.
Green 96, 97.
Holmgren 04.
Kingsbury 94.
Leydig 98.
Macallum 87.
Mc Gill 08a.
Mathews 99.
Meckel 19.
Miller 06.
Monti 98.
Nemiloff 02.
Oppel 95.
Platt 96.
Prenant 04.
Reese 04b.
Richter 02.
Riddle 09.
Saint-Hilaire 03.
Schulz 00.

8. Nervous System.

Allis 03.
Anderson 92.
Bender 07a.
Brachet 07.
Bugnion 74.
Carlson 06.
Deen 34.
Edinger 04.
Fischer, J. G. 43.
Galeotti 97.
Herrick 93, 94, 09.
Hirsch-Tabor 09.
Hoffmann 02.
Humphry 72.
Jelliffe 97.
Johnston, J. B. 03, 06.
Kingsbury 95a.
Klaussner 83.
Kühne 86.
Kupffer 06.
Levi 97.
Leydig 76a.
Macallum 87.
Mc Gill 08, 08a.
Mc Gregor 96.
Miller 00.
Monti 99.
Nakagawa 91.
Nemiloff 02.
Neumayer 06.
Norris 05, 08, 09.
Osborn 83, 84, 86, 86a, 88.
Platt 96a.
Rubaschkin 01, 03.
Ruge 97.
Smirnow 90.
Strong 92, 95.
Tuerckheim 03.
Vaillant 62.
Warren 05.

9. Sense Organs.

Bawden 94.
Beer 99.
Bugnion 73.
Dubois 90.
Eigenmann 00, 00a.
Eigenmann and Denny 00, 00a.
Eycleshymer 93.
Fleissig 09.
Hess 89.
Howard 08.
Kingsbury 95, 95b, 03, 08.
Kingsley 00.
Kingsley and Ruddick 99.
Kohl 89, 91.
Kuhn 79.
Lauber 02.
Leydig 68, 76b.
Loeb 05.
Malbranc 75, 76.
Mall 93.
Mihalkovics 98.
Norris 94.
Okajima 06.
Okasima 06.
Rabl 98.
Reese 05a, 06a.
Rejsek 97a.
Retzius 81, 04, 05.
Schlamp 91, 92.
Schulze, F. E. 61, 70.
Seydel 95.
Studnička 97.
Takahashi 09.
Terry 06.
Wilder, H. H. 92.
Wilder, J. W. 09.

10. Integument.

Ancel 01.
Chauvin 84.
Eycleshymer 06b.
Grote 76.
Heidenhain 93.
Leydig 73, 76, 76a.
Merkel 80.
Niclogu 93.
Rabl 95.
Reese 04b, 05.
Schuberg 93.
Studer 74.

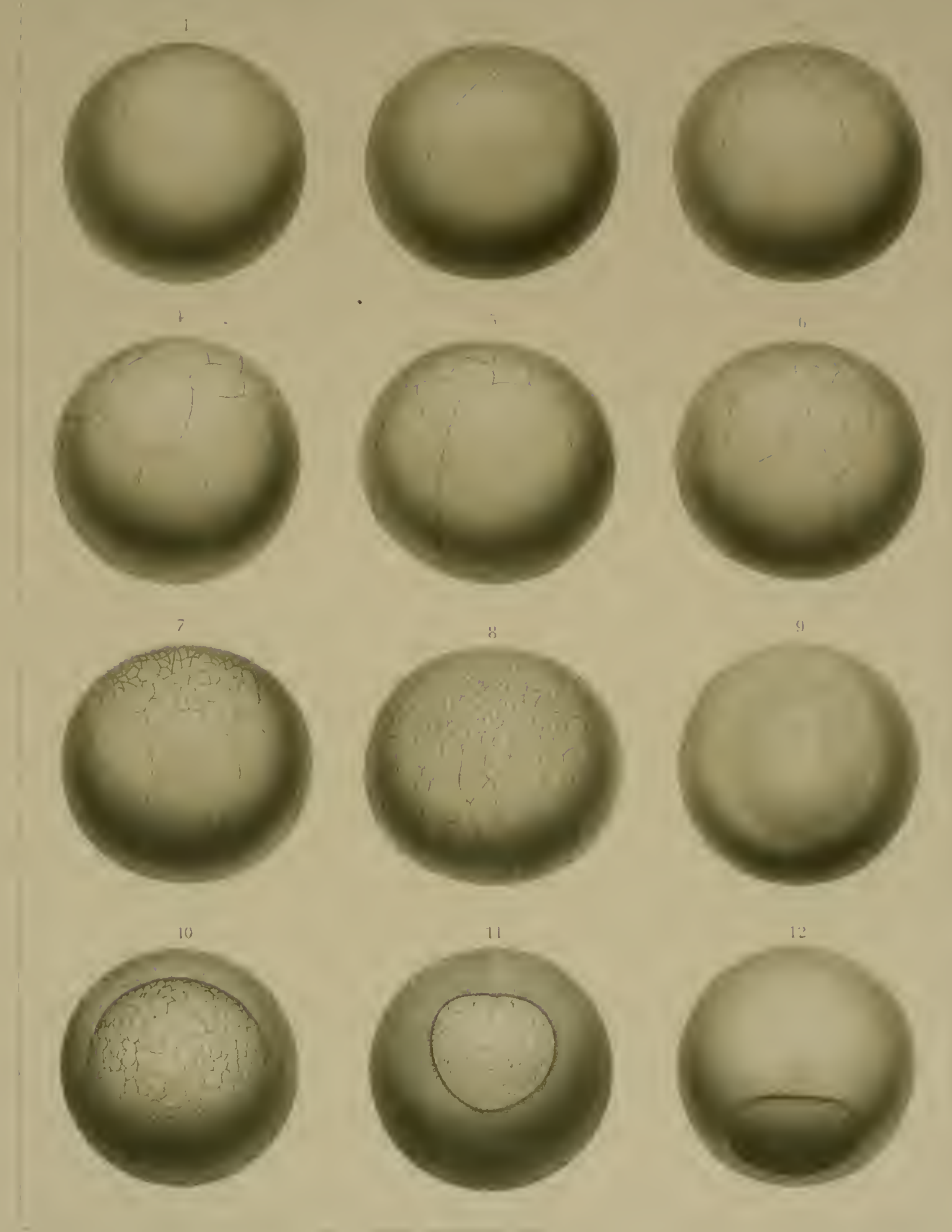
11. Genito-urinary Organs.

Bidder 46.
Broman 01.
Drzewina 03.
Duvernoy 47.
Felix and Bühler 06.
Field 94.
Fürbringer 77.
Hall 04.
Heidenhain 00.
Johnston, C. 76.
Joseph 05a.
Kampen 03.
Kingsbury 95.
Knappe 86.
Mc Gregor 99.
Meyer 75.
Minot 98.
Piersol 89.
Rathke 25.
Reese 04, 04a.
Valentin 41.

12. Variations.

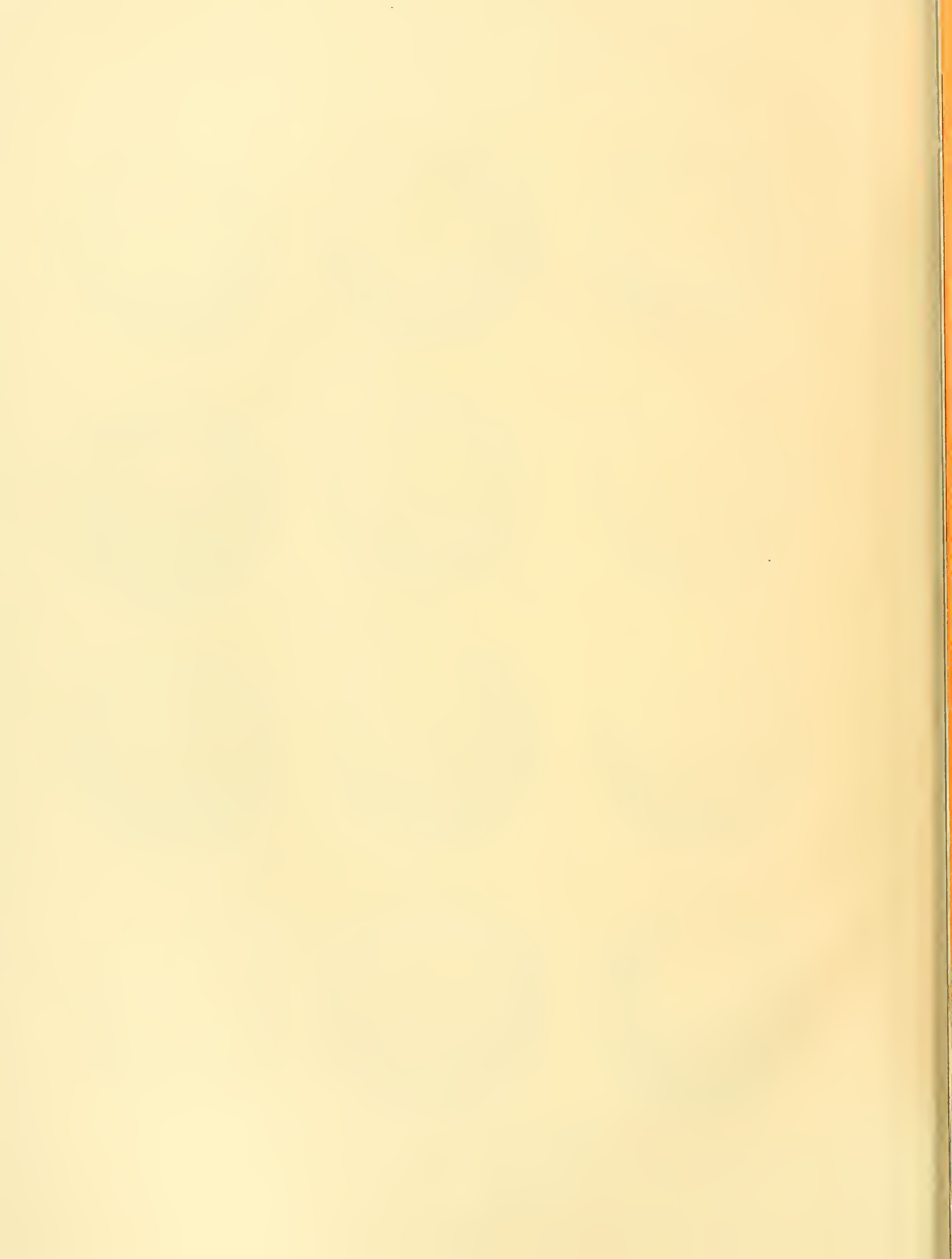
Bumpus 96.
Howes 93.
Waite 97.
Winslow 04.

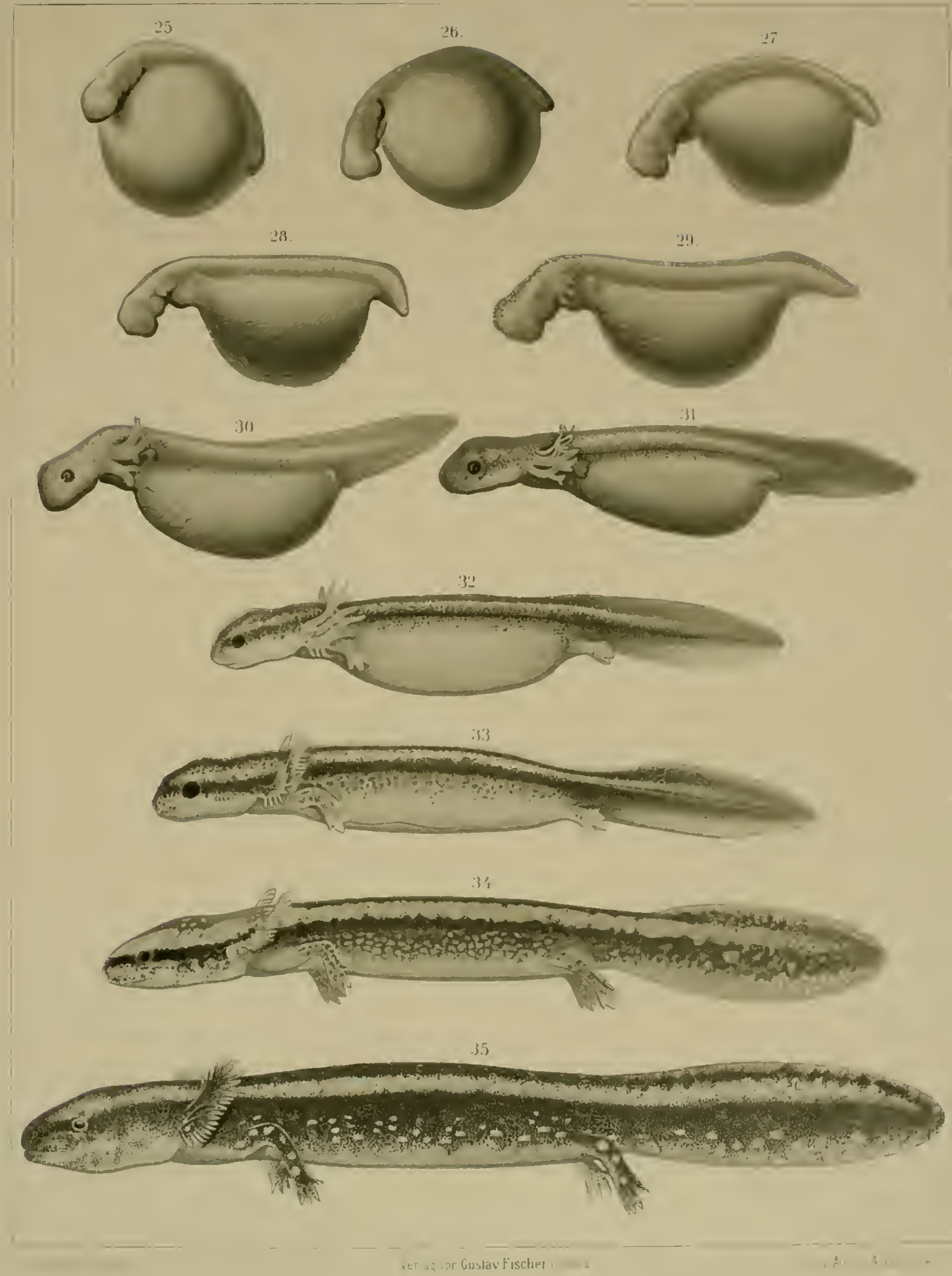
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1
4
5
6
7
8
9
10
11
12




13
14
15
17
18
19
20
21
22
23
24





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